Climate Change Technology

Needs Assessment (TNA) Project-Jordan

Report II

Barrier Analyses and Enabling Framework

(Final Version)

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ACRONYMS

AEE	Association of Energy Engineers
BA & EF	Barrier Analysis and Enabling Framework
BOM	Build-Operate-Maintain
BRT	Bus Rapid Transit
DTU	Technical University of Denmark
ED	Electrodialysis
EDR	Electrodialysis Reversal
GAM	Greater Amman Municipality
GHGs	Greenhouse Gases
GIZ	German Technical Cooperation
ISSP	Institutional Support & Strengthening Program (of USAID-Jordan)
ITM	Irrigation Management Transfer
JCP	Jordan Competitiveness Program
JISM	Jordan Institution for Standards and Metrology
JREEEF	Jordan Renewable Energy and Energy Efficiency Fund
JVA	Jordan Valley Authority
MCA	Multi Criteria Analysis
MEE	Multiple-Effect Evaporation (distillation)
MEMR	Ministry of Energy and Mineral Resources
MoEnv	Ministry of Environment
MOM	Management, Operation and Maintenance
MoPIC	Ministry of Planning and International Cooperation
MSF	Multi-Stage Flash (distillation)
MWI	Ministry of Water and Irrigation
NEPCO	National Electrical Power Company
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PV	Photovoltaic
R&D	Research and Development
RO	Reverse Osmosis
RWH	Rainwater Harvesting
SHS	Solar Home System
TTA	Task Transfer Agreement
UDP	UNEP-DTU Partnership
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
VCD	Vapour Compression Distillation

WAJ	Water Authority of Jordan
WUAs	Water Users Associations

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EXECUTIVE SUMMARY

The purpose of this Barrier Analysis and Enabling Framework (BA&EF) Report is to document the results of conducting a systematic and deep barrier analysis assessment for each priority technology of the four priority sectors (energy, transport, water, and agriculture) selected in Jordan for the TNA activities and exploring options (incentives or measures) to address the identified barriers. In addition, the process diagnosed the most optimized enabling framework for each technology individually as well as for the three top priority technologies together at the sectoral level. In this report, the barriers, measures, and enabling environment were identified for each priority technology in each sector using a systematic process, utilizing tools selected from the literature and best industry practices for such type of assessments. The procedure was set so that the preliminary targets for each sector were first determined, then barriers were diagnosed encompassing both financial and nonfinancial barriers. Then measures and incentives to overcome such barriers were introduced. In light of that, preliminary targets were revisited and refined based on the results of barrier analysis and elaboration of enabling framework.

The first step of BA&EF procedure of each prioritized technology was to use a methodical approach, mainly based on process' accompanying guidelines and tools recommended by *UDP* with emphasis o*n the* guidebook titled *"Overcoming Barriers to the Transfer and Diffusion of Climate Technologies - 2nd Ed.*" The barrier analysis of the proposed technologies was conducted based on, as a first step or initial work, extensive desk study and literature review. Then, deep analysis of policy papers and reports and other pertinent documents was conducted to identify the primary reasons why each of the three top priority technologies in each selected priority sector is not currently in widespread use and why neither the private nor public sectors have invested significantly in it. In particular, proper economic assessment (economic and financial barriers) of the selected technologies was included in the desk study, but also other relevant assessments, for example environmental, social impact, and institutional capacity assessments were also considered. The summaries of financial and other assessments of the selected technologies made available by the specialized sector's consultant before conducting the barriers identification process involving relevant stakeholders were also of great value for the barrier decomposition process. As an example, feasibility analyses conducted illustrated the cost of capital, and in particular, why the cost may be considered too high for the public or potential investors. Thus decomposing the barrier 'cost of capital' into its barrier elements and further into their dimensions was deduced from the feasibility summaries the consultants prepared. Stakeholder's analysis and focus groups meetings to establish stakeholders' engagement in barrier analyses process was a major step in identification of barriers and measures as well as enabling framework. Two specific tools were useful in assisting the analysis of the decomposition of barriers: the *root cause analysis*, and the *logical problem analysis (LPA)*, both of which were used herewith involving relevant stakeholders.

After conducting the barrier analyses part of the work, measures or incentives (solutions) were also assessed and identified to each barrier (economic and financial measures and non-financial measures). These measures will form the basis of the technology action plan (TAP) formulation, which will be the focus of the third (last) phase of the Project (expected to be completed in late 2016/early 2017). All the above steps were carried out with the support of dedicated stakeholders' participation and engagement meetings in the format of focus-group discussion workshops and results-oriented group exercises. The main action was identifying

all directly-relevant active stakeholders and experts to the particular technology under assessment so that invited stakeholders cover all aspects of the assessed technology. Such representative stakeholder pools were carefully selected from market and supply chain companies involved, key players from policy making/government, research, innovation and technology development (incubator) institutions, regulatory and governance parties, representatives of NGOs and farmers and Water Users Associations as well as competent and well-known economists in each particular sector. To that end, a focused two-day workshop was held in the *Dead Sea* area from 10-11 May 2016 where a total of 33 stakeholders attended the workshop representing all stakeholder categories mentioned above. In the said workshop, stakeholders embarked on serious and very fruitful and knowledge-producing discussions to identify and diagnose barriers and propose appropriate measures and incentives to assist wide dissemination and deployment of priority technologies.

Cost Benefit Analyses for the transfer and diffusion of the selected consumer technologies were conducted and inputs and outputs values as well as sensitivity analyses of the assessed models were also discussed supported with feedback from distinguished sector-involved economists who highlighted aspects and implications of estimates. The results and outcomes from BA&EF process for each sector will be summarized below.

Energy Sector:

For the energy sector, barriers were analyzed for each technology separately eventhough they have a lot in common. The specific barriers and thus responsive measures for each technology are presented in the energy chapter. The most common economical/financial and non-economical barriers for the three priority technologies (*solar PV electrification, solar water pumping* and *solar thermal technologies*) were: high initial system cost; inadequate of subsidies programs; high interest rates on loans; few skilled labor to install and maintain the systems; unfocused training; existence of low quality systems in the market; gap between existing legislation and actual implementation; weakness in enforcement of standards; inadequate awareness of the benefits of the solar technologies; inadequate public private partnerships; few manufacturers of systems; and bureaucracy. Both solar PV electrification and solar pumping technologies face a barrier that is not the case for solar thermal technology which is " insecurity – stealing of solar systems installed in remote areas". However, In solar thermal technology it is found that, "affordability of other competitors" is the major barrier due to mainly its lower initial cost.

With regard to measures and incentives outlined and recommended for the energy sector, the three technologies may become affordable through a combination of the following economic and financial measures and non- financial measures: i) Reasonable initial costs of components will be realized by encouraging the private sector to establish industries locally; ii) providing subsidies; iii) Government may guarantee banking loans.; iv) It is expected that establishment of focused training programmes for the three technologies will result in existence of critical mass of technicians in the country to undertake activities such as installation, repair and maintenance of systems. This is likely to result in low costs for installation, repair and maintenance of systems; v) Enforcement of standards will lead to high system reliability and better echo among customers; and vi) effective awareness programs that educate customers about the real feasibility of the solar technologies and its real maturity will lead to better diffusion of the three technologies.

With regard to the most viable enabling framework for the energy sector to enable wide dissemination and deployment of the three technologies, the following are the additionally needed complimentary measures, for the three solar technologies, to work side-by-side along with the government's currently prevailing enabling environment so that together such integrated measures will serve to overcome identified barriers and assist wide dissemination and deployment of the three priority technologies. The recommended enabling framework encompasses: (i) *Regulations*: There is a high need to review regulations based on inputs from suppliers and manufacturers.; (ii) *Standards*: There is still a big need to enforce national standards for solar technologies and to prepare further standards; (iii) *Capacity building*; (v) *Awareness*: This can be resolved by implementing real feasibility studies that show the real economic and environmental benefits of the technology based on life-cycle cost analysis.; (vii) *Initial cost*: The effect of the high initial cost of solar technologies can be mitigated by setting up of local assembling and manufacturing industries for certain parts and systems.; (vii) *Subsidies*: Although VAT is removed, removing income tax on solar technologies is a good tool of subsidies; and finally (viii) *Incentives*: To encourage electricity companies in Jordan to effectively involve in the business of the three technologies, some kind of incentives is still needed.

Transport Sector:

For the transport sector, the Bus Rapid Transit (*BTR)* technology was assessed and the barriers identified which in general were related to cost, in addition to deficiencies in stakeholder coordination and related policies. The main economical barriers identified were high investment cost and needs for subsidies to incentivize the operators. Other barriers are the insufficient land use planning regularity, political instability, bureaucracy, needs for well planned (developed) infrastructure, professional experts, institutionalizing the management, building capacities for technical knowledge, car dependent culture, needs for media campaign, and a transparent access to information.

After the first scoping session with stakeholders, bikes infrastructure was the second priority but after reviewing results by sector-directly involved experts, there was no adoption of this technology, so another scoping session was organized this time with the involvement of more decision-making stakeholders were they reordered the priorities using the Multi Criteria Analyses MCA exercise. In the repeated MCA, stakeholders replaced the bikes infrastructure with the pedestrians' infrastructure as new top national priority for transport sector. With regards to barriers for *Pedestrian Infrastructure* technology, possible barriers to implementing pedestrian walkways include economic and financial barriers, legal and regulatory barriers, technical barriers, network barriers, institutional and organizational barriers, information and awareness barriers, as well as social, cultural and behavioral barriers. Overcoming some barriers can lead to eliminating others, since many of the barriers are interlinked. Such issue can be a possible cause for the fancy *Abdoun Bridge* example highlighted in the transport sector's chapter, as it is considered quite luxurious, yet lacking the pedestrian walkway. Among of the non-financial barriers to implementation are the legal and regulatory barriers, as there exists a policy gap for the enforcement of sidewalk regulations, as well as the regulations that affect the pedestrian behaviors. Infrastructure regulations in Jordan are not yet according to international standards, which must be changed in order to enforce infrastructural development. Additionally, raw materials used in infrastructure must be standardized and enforced on infrastructure contracting companies. Meanwhile existing walkways can be rehabilitated in order to match pedestrian

needs. One major barrier to implementing walkways is the need for law enforcement for walkway regulations. This barrier has three causes, which are: accumulation of old barriers, lack of specialists, absence of monitoring. The lack of specialists is a result of hiring unqualified workforce who underestimates the importance of implementing walkways. While the absence of monitoring is caused by a primary absence of ethics, which is a result of low wages due to the country's economic situation.

With regard to economic and financial barriers for *Ticketing System* technology, the ticketing system doesn't need a high investment as other technologies because it doesn't need an infrastructure. It is counted as a management tool for the public transportation that ease the payments and cash circulation between the user, operator and the government. But here one can find the main barrier which is the lack of trust between the operator and the government. It will be so hard for the operator to be monitored by the government for the revenue of operating the public transport. With regard to non-financial barriers, the infrastructure for the ticketing system technology is not fully mature to be implemented in Jordan because the infrastructure of the public transportation is not very well developed and there are huge gaps and missing elements in integrating the diverse public transportation modes. The main challenges and barriers are summarized as lake of management for the public transportation in Jordan; vulnerable infrastructure for the public transportation; limited modes of public transportation to buses, white taxies, and yellow taxies; and mental maturity and lake of awareness of the importance of the public transportation.

Water Sector:

For the water sector's *Roof-top Rainwater Harvesting* technology, it was found out that, generally speaking, economic and financial aspects of this technology are not the major obstacles in the road of diffusion of such technology in Jordan in terms of amount of capital needed. However, it is the feasibility (payback period) that makes this technology unfavourable economically to many households. Results of systematic assessment of the economic and financial barriers of rooftop rainwater harvesting conducted for the TNA Project is provided in the Water Sector Chapter. Another economic barrier preventing a wide dissemination of such practice in Jordan is limited incentives from government to encourage households to approach such technology. With regard to non-financial barriers, the following barriers were identified as obstacles preventing wide spreading of this practice: *Information and Awareness Barriers*; *Human Skills Barriers; Market Condition Barriers*; and *Legal and Regulatory Barriers*.

For *Desalination/Brackish Water Treatment and Re-use* technology, assessments for economic and financial barriers revealed that the technology remains very expensive, making it currently impracticable for most applications. In Jordan, moreover, large-scale seawater desalination has no practicable path, since the only shorelines of the country is at Aqaba and on the Dead Sea, far away from the population and production centers. More convenient and thus more realistic in the short term is desalination of brackish water. To date, the desalination of either seawater or brackish water in Jordan has been very limited. This is further aggravated by the fact that centers of population are at high elevations (Amman 1000 m above mean sea level) and would therefore involve high pumping costs. Some other economic barrier facing flourishing of such technology in Jordan is that there is absence of directives to provide incentives to locally-produced

desalination units, especially spare parts. For non-financial barriers, the following were identified: *Technical Barriers; Information and Awareness Barriers*; *Human Skills Barriers*; and *Market Conditions Barriers*.

The most important economic and financial barrier *Water Users Association* (*WUAs*) technology is facing based on opinion of directly involved stakeholders representing the governmental body (Jordan Valley Authority-JVA) that is in charge of the affairs of WUAs at Jordan Valley is clear weakness in financial sustainability of such highly needed organizations. This is mainly due to inability to recover water costs, limited finance available for instance to rehabilitate the irrigation network; limited income-making projects; weakness of marketing and competitive abilities of framers' products. For non-financial barriers. They are: *Technical Barriers*; *Institutional and Organizational Barriers; Market Condition Barriers; Information and Awareness Barriers*; *Human Skills Barriers:* and *Legal and Regulatory Barriers*.

The recommended enabling framework for overcoming the barriers in the Water Sector was outlined as well. Based on the common economic/financial barriers for the two market technologies of roof-top harvesting and the desalination, it is strongly believed that an effective component of an enabling framework for both technologies is a governmental incentive of tax cut for both technologies to encourage household resident and farmers to purchase and install roof-top harvesting and desalination technology. Another component of the enabling framework for both technologies is developing robust awareness campaigns to increase the level of the public knowledge of the importance of such water conservation practices. It is clear that the two technologies of roof-top water harvesting as well as the WUAs practice on the other hand all share common barrier of big need for skillful human resources. Thus, an important element of an effective enabling framework for such technologies should address human skills-related barriers. In the case of WUAs, the enabling framework should focus on the high need for continuous training and capacity building programs specifically for financial sustainability skills and developing training programs on grant writing skills predominantly. At the legal and regulatory sphere, an element of the enabling framework targeting both rainwater harvesting and desalination would be directed to the barrier of absence of directives to provide incentives to locally-produced desalination units and to households that deploy rainwater harvesting structures. Thus, since the two technologies are approached under the mandate of MWI/Water Authority of Jordan (WAJ)'s regulatory system, the two technologies could be addressed concurrently in any future revision of the relevant laws, by-laws, regulations, etc, aiming at providing an enabling environment for the two technologies in the contexts of addressing climate change adaptation at the national level.

Agriculture Sector:

Finally, for agriculture sector, the economic and non-economic barriers were identified and assessed for the three priority technologies. The economic and financial barriers for *Water Saving Technologies, such as Drip or Subsurface Irrigation* Technology were mainly the large investments and high infrastructure costs needed. Higher costs are generally associated with the costs of pumps, pipes, tubes, emitters and installation. One important barrier of the implementation of the technology is weak capacity and limitation in technical knowledge and skills of farmers on application of water saving technologies. Another important barrier is the low level of awareness of economic and ecological advantages.

For *Water Harvesting* technology at the farm level, the economic and financial barriers as well as non-financial and technological barriers were identified. The insufficient governmental financial support for enhancement research activities in the application of this technology, weak access to financial sources, weak institutional basis and networking and unfamiliarity with the new technology were the main barriers hindering the diffusion of the technology.

For *Introduction of Plant Varieties Resistant to Climate Change* Technology, the economic and financial barriers as well as non-financial and technological barriers were identified. Insufficient governmental support for enhancement of research activities, lack of financial support for research institutions, weak capacity and lack of skills of existing research institutions, unfamiliarity with new technology and inefficient agricultural extension services are the main barriers hindering the diffusion of the technology.

The enabling environment for the agricultural sector should encompass the following main measures to enable the country to overcome identified economic/financial and non-financial barriers of the prioritized technologies: (i) enable provision of long-term and low-interest loans or grants through state/government funds, private sources (different banks) and international funds (for example, WB, IFAD, GEF, GCF, and Adaptation Fund); (ii) develop specific subsidy mechanism to promote application of the different technologies; (iii) integrate incentive polices for diffusion of the new technologies; (iv) develop capacity building programs for research institutions; (v) strengthen international research network programs; (vi) enhance and improve agricultural extension services; (vii) develop information campaigns on the advantages of applied technologies; (viii) develop capacity building activities; (ix) implement pilot projects at community (municipal) level; and (x) develop and implement specific capacity building activities to increase technical capacity of relevant technical experts. Capacity building activities include activities related to awareness raising and increase of knowledge of all related stakeholders such as decision-makers, technology users, and service providers of applied technology. These include organization of round-table discussions, training sessions, workshops, seminars and study tours for relevant technologies. It is considered an effective tool to raise awareness level of the advantages of the technology. This includes dissemination of information on technology advantages, as well as current opportunities for national and local decision makers and local communities (technology users), through mass media, publications, organization of workshops and seminars.

1. INTRODUCTION

1.1. Summary of Outcomes from the TNA Report (Report I or Phase I) of the Project

The first report produced from the activities of the TNA Project in Jordan, which is implemented through a partnership between *United Nations Environment Program* (*UNEP*) and *Technical University of Denmark* (*DTU*) or *UNEP-DTU Partnership*-(shortly "*UDP*"), was submitted to Jordan Ministry of Environment (MoEnv) on April 2016. The TNA activity was systematically conducted through a country-driven process, involving all relevant stakeholders and taking national sustainable development priorities into consideration. The national stakeholders were involved in the first phase of the TNA Project in two rounds of consultation. In the first round, the launching of the TNA project in Jordan took place in Nov 17th, 2015 where the approach and workplan of the assignment were presented and discussed to obtain feedback from stakeholders on them and brainstorm and identify relevant pools of stakeholder groups to involve in the activities and discussions of the project. In the said workshop, three exercises were conducted involving all attendees. The first exercise was for selection of priority mitigation and adaptation sectors for TNA activities, which was based on conducting a dedicated multi criteria analysis (MCA) exercise prepared purposely for this step utilized in addition to the standard MCA form proposed by *UDP* for selection of priority technologies. The two MCA exercises revealed that the top two priority mitigation sectors with regard to climate change technology needs in Jordan are *Energy* and *Transport,* while on the other hand the top two priority adaptation sectors 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 status of the energy and transport sectors as the two most emitters of GHGs in the country and their critical implications with regard to sustainable development (TNC 2014[1]). The same conclusion is valid for water and agriculture sectors as they are the two sectors most vulnerable to climate change in Jordan as shown in the extensive assessments conducted in some national studies, mainly the TNC study (2014)[2].

In round two of the stakeholders' involvement process of phase I of the project, *Mitigation and Adaptation Technical Working Groups* were invited to a two-day workshop to discuss and prioritize technologies of each priority sector based on the set criteria for each sector. Results of the four MCA exercises revealed the following top three technologies out of the long initial rosters of assessed technologies in each sector assessed in terms of priority: the top three mitigation technologies for energy sector were: (1) *Solar Thermal*, (2) *PV for Water Pumping*, and (3) *PV for Electrification*. The three top-ranked priority technologies for Transport Sector were (1) *Bus Rapid Transit*, (2) *Improving Pedestrian Infrastructure*, and (3) *Ticketing System*. The final results for water sector's top three priority adaptation technologies were (1) *Rainwater Harvesting*, (2) *Water Users Association*, and (3) *Desalination/Brackish Water Treatment and Re-use*. Finally, the final results for agriculture sector's top three priority adaptation technologies were (1) *Water Saving Technologies, such as Drip or Subsurface Irrigation*, (2) *Water Harvesting*, and (3) *Plant Varieties Resistant to Climate Change*.

Water harvesting 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 in such a water-poor country like Jordan. Having the above results available from the first phase of the TNA Project in

Jordan, the Project Team and national stakeholders involved in the first phase, along with the newly identified stakeholders were ready to proceed with the activities of the TNA Project in Jordan through the second Phase (barrier analysis and enabling framework or "BA & EF" phase). The second phase aims at assessing obstacles and limitations hindering wide dissemination and deployment of such technologies in order to outline measures (incentives) needed and also to outline the enabling frameworks to maximize and enhance wide-spreading of such technologies effectively and systematically in the long path to deal with climate change in Jordan.

1.2. Purpose of Barrier Analysis and Enabling Framework (BA & EF) Report (Phase II of the Project)

This report documents the results of a systematic barrier analysis assessment for each priority technology and exploring options (incentives or measures) to address the barriers. Also, the process entailed diagnosing the most optimized enabling framework for each technology as well as the three technologies together at the sector level. In the following chapters, the barriers and enabling measures will be identified for each priority technology within the priority sectors using a systematic process supported with tools selected from the literature and best industry practices for such type of assessment process. The procedure was set so that the preliminary targets for each sector were first determined, then barriers were diagnosed encompassing both financial and nonfinancial barriers. Then measures and incentives to overcome such barriers were introduced. In light of that, preliminary targets were revisited and refined based on the results of barrier analysis and elaboration of enabling framework.

The first step of the BA&EF procedure for each prioritized technology used the tools recommended in the guidebook *"Overcoming Barriers to the Transfer and Diffusion of Climate Technologies - 2nd Ed"*[3]. The procedure followed was first to identify and decide on the classification of a particular technology, i.e., market or non-market good and whether it is a "*consumer*" or "*capital*" good (for market goods) or "*publicly-provided*" or "*other non-market"* (for non-market goods). The barrier analysis of the proposed technologies was conducted based on, as a first step or initial work, extensive desk study and literature review. Then, deep analysis of policy papers and reports and other pertinent documents was conducted to identify the primary reasons why each of the three top priority technologies in each selected priority sector is not currently in widespread use and why neither the private nor public sectors have invested significantly in it. In particular, proper economic assessment (economic and financial barriers) of the selected technologies was included in the desk study, but also other relevant assessments, for example, environmental, social impact and institutional capacity assessments were also considered. The summaries of proper financial and other assessments of the selected technologies made available by each sector's consultant before conducting the barrier identification process were also of great value for the barrier decomposition process. As an example, feasibility analyses conducted illustrated the cost of capital, and in particular, why the cost may be considered too high for the public or potential investors. Thus decomposing the barrier 'cost of capital' into its barrier elements and further into their dimensions was deduced from the feasibility summaries the consultants prepared. Two specific tools were useful in assisting the analysis of the decomposition of barriers: the *root cause analysis* and the *logical problem analysis (LPA)*, both of which were used (which are further elaborated in Annex A of the said guidebook[4]). After conducting the barrier analyses part of the work, measures or

incentives (solutions) were identified to each barrier (economic and financial measures and non financial measures).

All the above steps were aided with conducting dedicated stakeholder participation and engagement meetings in the format of focus-group discussion workshops and results-oriented group exercises. A very careful identification of the to-be-invited representatives of stakeholders to the BA&EF consultation workshop was carried out before holding the workshops. The main action was to identifying all directly-relevant active stakeholders and experts to the particular technology under assessment so that they cover all aspects of the assessed technology. Such representative stakeholders were from market and supply chain involved companies, key players from policy making/government, research, innovation and technology development (incubator) institutions, regulatory and governance parties, representatives of NGOs and farmers and Water Users Associations as well as competent and well-known economists in each particular sector. Parallel with this brainstorming process and workshop's material preparation, it was concluded that a two-day extensive workshop in a remote place from the capital city of Amman would be an appropriate logistic to conduct the stakeholders'' consultation workshop to isolate participants from all means of distraction and get the most benefit and needed added-value feedback from participants. Thus, a focused two-day workshop was held in the Dead Sea area from 10-11 May 2016 (agenda is presented in Annex 1). A total of 33 stakeholders attended the workshop (attendees roster sheets showing the affiliation of participants and the sector they represent is posted in Annex 2) representing all stakeholder categories mentioned above. As shown in the photos from the workshops (Figures 1-2) stakeholders embarked on serious and very fruitful and knowledge-producing discussions.

Cost Benefit Analysis (CBA) for the transfer and diffusion of selected consumer technologies was also conducted (Annexes 3-6) and input and outputs values as well as sensitivity analyses of the model were also discussed supported with feedback from distinguished sector-involved economists who highlighted aspects and implications of estimates. However, economics experts (Figure 2) stressed that the used *UDP* models were basic ones and more in-depth CBA estimates using advanced models might be needed to better estimate the real cost and benefit of particular technologies.

1.3. A brief Step-by –Step Outline of the BA& EF Process Followed

The procedure followed in the BA & EF Process was as followed:

- Identification and analysis of barriers to the transfer and diffusion of climate technologies (both market goods and non-market goods) in order to establish a sufficient basis for developing measures to overcome them (translating barriers into solutions);
- Identifying barriers was perceived as tracing the *reasons* that are obstructing the transfer and diffusion of technologies;
- The primary task was to understand the nature of the individual barriers and the relations between barriers, determine which barriers are important, and identify barriers that are easier to remove;

- A thorough understanding of the barriers to the transfer and diffusion of climate technologies was the key to designing the appropriate portfolio of measures to overcome them. This also helped assessing the costs and benefits of measures;
- General steps in identifying and analyzing barriers were:
    - Organising the process
    - Screening of barriers
    - Listing all identified barriers
    - Selecting the most essential barriers
    - Decomposing the selected essential barriers
    - Logical deduction of barriers (problem tree)
- Categorizing of barriers into major thematic categories:
    - *Technical*
    - *Economic & Financial*
    - *Market Conditions*
    - *Legal and Regulatory*
    - *Network*
    - *Institutional and Organizational Capacity*
    - *Human Skills*
    - *Social, Cultural and Behavioral*
    - *Information and Awareness*
    - *Other (*environmental impacts, physical infrastructure conditions)
- For market-goods technologies (consumer goods and capital goods), which are expected to be diffused in large numbers under market conditions, the market-mapping technique were used to identify market barriers more systematically.
- Screening Barriers

- Barrier identification resulted in a long list of barriers gleaned from various documents, interviews and/or the open-minded and nonselective recording of all ideas suggested by workshop participants;
- When all the conceivable barriers have been identified, they were screened according to their significance. Workshop participants argued for and against the listed barriers to reach agreement by consensus or majority;
- Most important was to identify the essential barriers – that is, the barriers which definitely need to be addressed for technology transfer and diffusion to occur – as well as the non-essential barriers that are to be discarded and subsequently ignored;
- Barriers were also sorted according to who has the power to do something about it and who is driving change: e.g. the national government, local authorities or power utilities.

- Measures to overcome barriers
  - Having established a thorough understanding of the barriers to the transfer and diffusion of technologies, the next step was to analyze how these barriers can be removed or overcome;
  - In this procedure followed (based on the UDP guidebook[5]), the term '*measure*' was used as a general concept for any factor (financial or nonfinancial) that enables or motivates a particular course of action or behavioral change with the objective of overcoming a barrier. In the literature, the word '*incentive*' is often used synonymously with 'measure'.
  - Grouping measures and design of programme. This step involved:
    - Applying a relatively broad set of complementary measures addressing barriers at various levels;
    - Measures were classified into two main groups: financial and non-financial measures, as it is of importance to policy-makers which measures can be implemented by legal or other interventions, and which measures need to be financed (nationally or externally).
  - Assessing measures and sets of measures to be included in the Technology Action Plan (TAP)
    - At the end of the assessment and grouping process, several competing sets of measures may have been identified, each of them leading to a similar outcome, but with different costs and benefits.

- In order to prepare an optimum selection of measures for policy-makers, they were assessed in terms of their impacts and their costs. This is a three-step exercise establishing:
    - the effect of each measure and the combination of measures (program)
    - the societal benefit of the programme
    - the cost of the measures included in the program

Figure 1: A photo from BA&EF consultation workshop held from 10-11 May 2016

Figure 2: Another photo from BA&EF consultation workshop held from 10-11 May 2016

2. ENERGY SECTOR

2.1. Preliminary Targets for Technology Transfer and Diffusion for Solar PV Electrification, Solar Water Pumping and Solar Thermal Technologies

Jordan imports around 96% of its energy needs, which accounts for one fifth of the country's GDP. Due to both economic and population growth, demand for electricity has been and is growing steadily at an annual rate of around 10%[6]. The Ministry of Energy and Natural Resources (MEMR) drafted the National Energy Strategy (2007-2020) to implement ways to develop conventional, renewable and alternative resources-wind, solar, oil shale and nuclear. Expected investments in the sector are around $1.4 – 2.1 billion through 2020. Contribution of the renewable energy to the energy mix is set to rise from 1% in 2007 to reach 7% by 2015 and 10% by 2020[7]. Renewable energy generation will be composed of 600 – 1000 MW from Wind, 300–600 MW from Solar and 30 – 50 MW from Waste.

Several projects with a total capacity of 400 MW were already allocated in two 200-megawatt tender rounds in Jordan. *First Solar* signed a Build-Operate-Maintain (BOM) contract with the Jordanian Government for the 52.5 MW *Shams Ma'an Solar PV Power Plant*, with a 20-year power purchase agreement (PPA). Construction of the plant is expected to finish in 2016[8]. The *Shams Ma'an* project was tendered in the first round and granted a tariff of US 14.8¢ per kilowatt-hour. The second round drew record-low tariffs of 6 and 7 cents per kilowatt hour for each of the four 50-megawatt projects (US 6.13¢, 6.49¢, 6.91¢ and 7.67¢ per kWh), which are not much above the world record tariff of US ¢5.89 per kWh tendered in early 2015 for the second phase of the *Mohammed bin Rashid Al Maktoum Solar Park* in the United Arab Emirates. Moreover, a plan to install solar PV electrification systems at all 6000 mosques in the country was announced in February 2015[9]. According to the 2013 Annual Report of MEMR, power requirements for water pumping alone in 2013 amounted to about 14% of the total power production of Jordan with a total amount of 1424 GWh.

In terms of energy efficiency in this sector and according to the Ministry of Water and Irrigation's (MWI) "2015 *Energy Efficiency and Renewable Energy Policy for the Jordanian Water Sector*", the energy targets of MWI for the year 2025 are specifically:

- Reducing the overall energy consumption in public water facilities by 15%;
- Increasing the share of renewable energy to 10% of the overall power supply;

With regard to solar thermal, about 15% of all households in the country are equipped with solar water heating systems. As per the Energy Master Plan, 30 % of all households are expected to be equipped with solar water heating system by the year 2020. Three priority technologies of the energy sector have the solar power as a common input and as a result of the literature survey conducted as well as discussions with stakeholders and experts, it was found out that the three technologies greatly share many common barriers. However, the sections below discuss barriers for the three technologies separately, but it should be taken into consideration the common broad lines they may share.

2.2. Barrier Analysis and Possible Enabling Measures for Solar PV

2.2.1. General description of solar PV electrification

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. Photovoltaic (PV) system convert sunlight into electricity that can be used in different applications such as:

- 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 centralized PV – providing centralized power generation for the supply of bulk power into the grid.

2.2.2. Identification of barriers for solar PV electrification

To identify barriers of this technology and the other two priority technologies of the sector, the following process was used:

i) Reviewing relevant policy papers and other pertinent documents;

ii) Economic feasibility study using Excel templates;

iii) Workshop including stakeholders from the government and private sector (Figure 3).

iv) Consultations with experts and stakeholder; and

v) Market mapping tool-consumer goods and capital goods.

Market mapping, which is a process used to understand the marketing aspects of each technology as well as key players and barriers, was utilized in the assessment process. It was necessary to identify the chain and relation between all players to identify barriers that hinder the diffusion of the targeted technologies. One of the levels in the market chain is to map the actors who take part in the chain from consumer to importation or production of the product and to establish the flow of actions between them. The solar market in Jordan is in general distributed among PV solar electrification, PV solar water pumping and solar thermal technologies. The three technologies share many common barriers with some specific characteristics for each technology. The next level in the market chain comprises retailers and wholesalers of systems. Local production or assembling of components or systems can create jobs and may reduce costs.

Figure 3. A photo of Energy Sector's market and nonmarket stakeholders participated in the BA&EF consultation workshop held on May 10-11, 2016.

As a result of market mapping brainstorming and assessments (Annex 3), the following main barriers were identified:

- High initial system cost;
- Inadequacy of subsidy programs;
- High interest rates on loans;
- Few skilled labour to install and maintain the systems;
- Unfocused training;
- Existence of low quality systems in the market;
- Insecurity – stealing of solar systems specially those installed in remote areas;
- Gaps between existing legislation and actual implementation;
- Weakness in enforcement of standards;
- Inadequate awareness of the benefits of the solar technologies;
- Few manufacturers of systems; and
- Bureaucracy

As barriers can be classified under several categories, it is found important to specify each barrier to better understanding the problem. The table below (Table 1) shows the category of each barrier.

Table 1: Categories of barriers identified for energy sectors' top three priority technologies

Barrier	Category
High initial system cost	Economic and financial
High interest rates on loans	Economic and financial
Inadequate of subsidy programs	Economic and financial
Limited Number of Local skilled labour to install and maintain the systems	Human skills
Existence of low quality systems	Legal and regulatory
Insecurity – stealing of solar systems	Social
Gap between existing legislation and actual implementation	Legal and regulatory
Inadequate awareness of the benefits of the solar technologies	Information and awareness
Few manufacturers of systems	Technical, legal and regulatory
Bureaucracy	Legal and regulatory

To identify the main starter barriers, logical Problem Analysis was used (Annex 3) as a tool in the analysis. After conducting thorough and detailed barrier analysis involving sector's key players (Figure 3) and desktop work, the main starter barrier was identified as "The high initial system cost." This method `was used to also identify the root cause of the barriers in which case all problems/barriers were arranged around a starter problem. All identified problems were ordered in a hierarchy of cause-effect relations with starter problem in the center and the direct causes below it and direct effects above. The problem tree includes screened barriers, which were decomposed in close consultation with the stakeholders. Annex 3 shows a problem tree for the technologies indicating causes and effects.

2.2.2.1. Economic and financial barriers

The following section discusses the economic and financial barriers to transfer and diffusion of PV electrification, technology in Jordan.

i) High initial system cost

Although a great reduction in prices has been achieved during the last few years, solar powered technologies still face a challenge in its high initial cost. Many customers in Jordan look to the initial cost of the project without focusing on the feasibility of the system. Feasibility studies in Jordan revealed that solar powered technologies have reached the breakeven and in some cases showed better indicators over the conventional technologies. For large-scale projects where detailed feasibility is required, this barrier is not foreseen. However, for small-scale projects, it is still a clear barrier. Moreover, for large scale projects where financing is required from banks, the high initial system cost is becoming a barrier due to the high interest rates of the local banks. This becoming less effective in foreign investment projects that seek external loans from international banks with lower interest rates.

ii) High interest rates

Banks in Jordan charge interest rates ranging between 6% and 9% for people wishing to get loans for solar technologies. This high interest rate highly affects the feasibility of the solar technologies that require high

initial cost and long period of loan. As PV projects normally require high capital cost, the loan normally extends over many years. As the result of the high interest rate, the payback period of the system increases considerably. In comparison to other countries, China for example where interest rates ranges between 0.5% to 4%, the economic feasibility of PV systems installed in Jordan is highly affected by the interest rate.

iii) Inadequacy of subsidy programs

The government of Jordan provides limited subsidies for such technologies such as the subsidized lower interest rate through international programs with local banks. Therefore, with its high initial cost such technologies are not easy to be accessible for low-income people with limited subsidy programs.

2.2.2.2. Non-financial barriers

i) Limited number of local skilled labour to install and maintain the systems

Universities in Jordan offer theoretical courses on solar energy. Practical training is not effective in the university level. There are some international certified courses provided like that of the *Association of Energy Engineers (AEE)*. Although it is a good step but still not sufficient in the technical and practical perspectives. As a result, the country has limited number of trained technical personnel to install, repair and maintain solar powered systems. Vocational training programs recently established are promising but so far not effective due to the lack of real solid base professional trainers. The Jordan Competitiveness Program (JCP) finance by USAID focuses on creating jobs and training. It subsidizes several training courses for women through the AEE programs.

ii) Existence of low quality systems

Due to inadequate legal and regulatory framework, low quality system components are imported to the country. Low quality components are unreliable and break down or degrade in efficiency shortly after installation. This will in turn result in prevailing of long-term problems in operation and maintenance. The reason for availability of such components, mainly from China, is the lower prices considering good quality components will increase the initial system cost. Regulations is required in this regard but not in a way that may increase capital system cost.

iii) Insecurity – stealing of solar systems

This problem happens frequently in systems installed in remote areas. Poverty of local people and the high unemployment rates within such remote communities most probably lead to this behavior.

iv) Gaps between existing legislation and actual implementation

Jordan Institution for Standards and Metrology (JISM) has started adopting several international standards. However, implementation is still not effectively applied due to lack of enforcement of regulations.

v) Inadequate awareness of the benefits of the solar technologies

The majority of Jordanians still have little information concerning the potential social, economic and environmental benefits of the solar powered technologies. Moreover, most of them do not have clear

understanding of the real economic feasibility of the system considering the life cost analysis rather than looking just to the initial investment. Lack of awareness programs about the maturity and reliability of the systems still make people reluctant of buying new technologies.

vi) Few manufacturers of systems

There is only one manufacturer for PV modules in Jordan. Due to that, the cost is still high. Availability of local manufacturers gives confidence among customers concerning long-term operation of the systems due to the affordability of components locally. Moreover, availability of local manufacturers lead to better reliability due to the adaptation of components to the local situation. This issue is becoming clear in solar water heaters that suffer technical problems of imported systems.

vii) Bureaucracy

Bureaucracy in grid connected systems in both procurement and installation procedure hinders the widespread dissemination of this technology. In many situations, it may require several months of waiting time to get approval from local authorities.

2.2.3. Identified measures

The technology may become affordable through a combination of the following economic and financial measures and non- financial measures.

2.2.3.1. Economic measures

i) Low costs for solar PV electrification technology will be realized by encouraging the private sector to establish industries locally. Support structure is an easy industry to be established locally. As there is only one module manufacturer in Jordan, other competitors may help in reducing prices;

ii) Considering that solar technologies are exempted from sales tax, exemption from income tax will reduce initial costs;

iii) Providing subsidies by seeking international environmental programs and other aids that have such initiatives. An example of the current situation is a grant from the gulf countries to establish PV power station in Jordan;

iv) Government may guarantee banking loans or cooperate with local banks to reduce interest rate;

v) Encourage insurance companies to cover PV systems

2.2.3.2. Non-economic measures

i) It is expected that establishment of focused training programmes (including both university and vocational training institutions in Jordan) will result in existence of critical mass of technicians in the country to undertake activities such as installation, maintenance and operation of systems. This is likely to result in low costs for installation, repair and operation.

ii) Enforcement of standards will lead to better quality of systems and lower maintenance requirements. This will lead to high system reliability and better echo among customers;

iii) Effective awareness programs that educate customers about the real feasibility of the solar technologies and its real maturity will lead to better diffusion of the technology.

2.3. Barrier Analysis and Possible Enabling Measures for Solar PV Pumping Technology

2.3.1. General description of solar PV pumping technology

A solar water pumping system consists of 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. Some of the 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.

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. Solar pumping system experience in Jordan dates back to early 1970s. Locally manufactured products can work for over 20 years with minimal maintenance.

2.3.2. Identification of barriers for PV pumping technology

As a result of market mapping brainstorming and assessments (Annex 3), the following main barriers were identified for PV pumping technology:

- High initial system cost;
- Inadequacy of subsidy programs;
- High interest rates on loans;
- Few skilled labour to install and maintain the systems;
- Unfocused training;
- Existence of low quality systems in the market;
- Insecurity – stealing of solar systems specially those installed in remote areas;
- Weakness in enforcement of standards;
- Inadequate awareness of the benefits of the solar technologies;
- Few manufacturers of systems; and

As barriers can be classified under several categories, it is found important to specify each barrier to better understanding the problem. The table below (Table 2) shows the category of each barrier.

Table 2: Categories of barriers identified for energy sectors' top three priority technologies

Barrier	Category
High initial system cost	Economic and financial
High interest rates on loans	Economic and financial
Inadequate of subsidy programs	Economic and financial
Limited Number of Local skilled labour to install and maintain the systems	Human skills
Existence of low quality systems	Legal and regulatory

Insecurity – stealing of solar systems	Social
Inadequate awareness of the benefits of the solar technologies	Information and awareness
Few manufacturers of systems	Technical, legal and regulatory

To identify the main barriers, the same logical Problem Analysis was used (Annex 3) involving sector's key players (Figure 3) supported with desktop work. The main starter barrier was identified as "The high initial system cost". Annex 3 shows a problem tree for the technologies indicating tied causes and effects.

2.3.2.1. Economic and financial barriers

The following section discusses the economic and financial barriers to transfer and diffusion of PV pumping technology in Jordan

i) High initial system cost

The cost of PV pumping systems comprises four main components: 1) PV modules, which has witnessed sharp reduction; 2) Inverter, which is a specialized components still undergoes development for large scale applications. Its cost is normally higher than standard PV inverter; 3) Motor-pump set which is a mature technology that has stable prices and 4) the balance of systems (BOS) which has almost same prices like that of PV electrification technology. Although a great reduction in prices has been achieved during the last few years in PV panels, solar pumping technologies still face a challenge in its high initial cost. Many customers in Jordan look to the initial cost of the project without focusing on the feasibility of the system. Feasibility studies in Jordan revealed that solar powered technologies have reached the breakeven and in some cases showed better indicators over the conventional technologies. For large-scale projects where detailed feasibility is required, this barrier is not foreseen. However, for small-scale projects, it is still a clear barrier. Moreover, for large scale projects where financing is required from banks, the high initial system cost is becoming a barrier due to the high interest rates of the local banks. This becoming less effective in foreign investment projects that seek external loans from international banks with lower interest rates.

ii) High interest rates

In small scale applications, this kind of systems is normally required by farmers to replace diesel generators. Large systems may be adopted by utilities like the Water Authority of Jordan (WAJ) for its pumping and booster stations. Both fields of applications may require loans. Banks in Jordan charge interest rates ranging between 6% and 9% for people wishing to get loans for solar technologies. This high interest rate highly affects the feasibility of the solar technologies that require high initial cost and long period of loan. For large scale PV pumping systems that need high capital cost, the loan normally extends over many years. As the result of the high interest rate, the payback period of the system increases considerably. Like in the solar PV electrification case, in comparison to other countries, China for example where interest rates ranges between 0.5% to 4%, the economic feasibility of PV systems installed in Jordan is still highly affected by the interest rate

iii) Inadequacy of subsidy programs

The government of Jordan provides limited subsidies for such technologies such as the subsidized lower interest rate through international programs with local banks. Therefore, with its high initial cost such technologies are not easy to be accessible for low-income people with limited subsidy programs. Normally farmers suffer loads of difficulties in Jordan and it will not be easy to tolerate the high initial system cost with subsidy.

2.3.2.2. Non-financial barriers

i) Limited number of local skilled labour to install and maintain the systems

Good number of academic institutions in Jordan offer theoretical courses on solar energy. However, applied training is not effective at the university level. In lieu, there are some international certified courses provided like that of the *Association of Energy Engineers (AEE)*. Although it is a good step but still not sufficient in the technical and practical perspectives. As a result, the country has limited number of trained technical personnel to install, repair and maintain solar powered systems. . Vocational training programs recently established are promising but so far not effective due to the lack of real solid base professional trainers. The Jordan Competitiveness Program (JCP) finance by USAID focuses on creating jobs and training. It subsidizes several training courses for women through the AEE programs.

ii) Existence of low quality systems

Due to inadequate legal and regulatory framework, low quality system components are imported to the country. Low quality components are unreliable and break down or degrade in efficiency shortly after installation. This will in turn result in prevailing of long-term problems in operation and maintenance. The reason for availability of such components, mainly from China, is the lower prices considering good quality components will increase the initial system cost. Regulations is required in this regard but not in a way that may increase capital system cost.

iii) Insecurity – stealing of solar systems

PV pumping systems normally installed in farms located in remote areas to replace diesel generators. Therefore it may be subjected to stealing of some components. This problem happens frequently in systems installed in remote areas. Poverty of local people and the high unemployment rates within such remote communities lead to this behavior.

vi) Inadequate awareness of the benefits of the solar technologies

The majority of Jordanians still have little information concerning the potential social, economic and environmental benefits of the solar powered technologies. Moreover, most of them do not have clear understanding of the real economic feasibility of the system considering the life cost analysis rather than looking just to the initial investment. Lack of awareness programs about the maturity and reliability of the systems still make people reluctant of buying new technologies.

v) Few manufacturers of systems

There is only one manufacturer for PV modules in Jordan. Due to that, the cost is still high. Availability of local manufacturers gives confidence among customers concerning long-term operation of the systems due to the affordability of components locally. Moreover, availability of local manufacturers lead to better reliability due to the adaptation of components to the local situation. This issue is becoming clear in solar water heaters that suffer technical problems of imported systems.

2.3.3. Identified measures

The elements in the market environment and the relation to the market chain were used to identify barriers for solar PV pumping technology. As a result, the following measures to promote transfer and diffusion of this technology were identified by the stakeholders. The technology may become affordable through a combination of the following economic and financial measures and non- financial measures.

2.3.3.1. Economic measures

i) Low costs for solar pumping technology will be realized by encouraging the private sector to establish industries locally. Support structure is an easy industry to be established locally. As there is only one module manufacturer in Jordan, other competitors may help in reducing prices;

ii) Considering that solar technologies are exempted from sales tax, exemption from income tax will reduce initial costs;

iii) Providing subsidies by seeking international environmental programs and other aids that have such initiatives. An example of the current situation is a grant international programs that provide farmers with PV pumping systems for trial purposes so as to promote this technology among users. Moreover, many PV pumping systems have been installed in Jordan for Bedouins in remote areas. These systems were granted to the WAJ through several research programs

iv) Government may guarantee banking loans or cooperate with local banks to reduce interest rate;

v) Encourage insurance companies to cover PV systems

2.3.3.2. Non-economic measures

i) It is expected that establishment of focused training programmes (including both university and vocational training institutions in Jordan) will result in existence of critical mass of technicians in the country to undertake activities such as installation, maintenance and operation of systems. This is likely to result in low costs for installation, repair and operation;

ii) Enforcement of standards will lead to better quality of systems and lower maintenance requirements. This will lead to high system reliability and better echo among customers;

iii) Effective awareness programs that educate customers about the real feasibility of the solar technologies and its real maturity will lead to better diffusion of the technology.

2.4. Barrier Analysis and Possible Enabling Measures for Solar Thermal Technology

2.4.1. General description of solar thermal technology

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. 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. 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. 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. Solar thermal experience in Jordan dates back to early 1970s. Based on the this study energy sector consultant's experience that dates back from 1990, locally manufactured products can work for over 20 years with minimal maintenance.

2.4.2. Identification of barriers for solar thermal technology

As a result of market mapping brainstorming and assessments (Annex 3), the following main barriers were identified for solar thermal technology:

- High initial system cost;
- Inadequacy of subsidy programs;
- High interest rates on loans;
- Few skilled labour to install and maintain the systems;
- Unfocused training;
- Existence of low quality systems in the market;
- Weakness in enforcement of standards;
- Inadequate awareness of the benefits of the solar technologies;
- Locally manufactured systems can not pass international standards ; and
- Affordability of other competitors for the solar thermal technology

As barriers can be classified under several categories, it is found important to specify each barrier to better understanding the problem. The table below (Table 3) shows the category of each barrier.

Table 3: Categories of barriers identified for energy sectors' top three priority technologies

Barrier	Category
High initial system cost	Economic and financial
High interest rates on loans	Economic and financial
Inadequate of subsidy programs	Economic and financial
Limited Number of Local skilled labour to install and maintain the systems	Human skills
Existence of low quality systems	Legal and regulatory
Inadequate awareness of the benefits of the solar technologies	Information and awareness
Locally manufactured systems cannot pass international standards	Technical, legal and regulatory
Affordability of other competitors for the solar thermal technology	Technical, Economic and financial

2.4.3. Economic and financial barriers

The following section discusses the economic and financial barriers to transfer and diffusion of solar thermal technology in Jordan

i) High initial system cost

There are two main applications in solar thermal field: 1) solar water heaters to heat water for domestic or industrial use; and 2) concentrated technologies for water heating and/or electricity generation. For domestic solar water heaters, although the system cost is not that high, other technologies have much lower initial cost. However, these kind of technologies require electricity, which means high running cost at the time where solar system enjoys free energy from the sun. Many customers in Jordan look to the initial cost of the project without focusing on the feasibility of the system. Feasibility studies in Jordan revealed that solar powered technologies have reached the breakeven and in some cases showed better indicators over the conventional technologies. For large-scale concentrated projects solar thermal still face the challenge of the high initial cost and also feasibility in comparison to conventional alternatives. Moreover, for large scale projects where financing is required from banks, the high initial system cost is becoming a barrier due to the high interest rates of the local banks. This becoming less effective in foreign investment projects that seek external loans from international banks with lower interest rates.

ii) High interest rates

In small scale applications, this kind of system is normally required for domestic use. Many trading companies offer installments but they imply interest rate in their price which leads to higher system cost. Large systems normally need loans from banks. Banks in Jordan charge interest rates ranging between 6% and 9% for people wishing to get loans for solar technologies. This high interest rate highly affects the feasibility of the solar technologies that require high initial cost and long period of loan. For large scale solar thermal systems that need high capital cost, the loan normally extends over many years. As the result of the high interest rate, the payback period of the system increases considerably. In comparison to other countries, China for example where interest rates ranges between 0.5% to 4%, the economic feasibility of PV systems installed in Jordan is still highly affected by the interest rate, the same conclusion as in Solar PV and solar pumping technologies.

iii) Inadequacy of subsidy programs

The government of Jordan provides limited subsidies for such technologies such as the subsidized lower interest rate through international programs with local banks and revolving funds. Therefore, with its high initial cost such technologies are not easy to be accessible for low-income people with limited subsidy programs.

2.4.4. Non-financial barriers

i) Limited number of local skilled labour to install and maintain the systems

Universities in Jordan offer theoretical courses on solar energy. Practical training is not effective in the university level. There are some international certified courses provided like that of the *Association of Energy*

Engineers (AEE). Although it is a good step but still not sufficient in the technical and practical perspectives. As a result, the country has limited number of trained technical personnel to install, repair and maintain solar powered systems. . Vocational training programs recently established are promising but so far not effective due to the lack of real solid base professional trainers. The Jordan Competitiveness Program (JCP) finance by USAID focuses on creating jobs and training. It subsidizes several training courses for women through the AEE programs.

ii) Existence of low quality systems

Due to inadequate legal and regulatory framework, low quality system components are imported to the country. Low quality components are unreliable and break down or degrade in efficiency shortly after installation. This will in turn result in prevailing of long-term problems in operation and maintenance. The reason for availability of such components, mainly from China, is the lower prices considering good quality components will increase the initial system cost. Regulations is required in this regard but not in a way that may increase capital system cost.

iii) Inadequate awareness of the benefits of the solar technologies

The majority of Jordanians still have little information concerning the potential social, economic and environmental benefits of the solar powered technologies. Moreover, most of them do not have clear understanding of the real economic feasibility of the system considering the life cost analysis rather than looking just to the initial investment..

vi) Locally manufactured systems can not pass international test standards

There are few local manufacturers of flat plate solar water heaters. It is of small scale industries that use steel as the heat transfer element instead of cupper. This leads to lower efficiency in comparison to products manufactured according to international standards. As local products does not have test certificates, customers become reluctant of buying such products. On the other hand imported high quality products are expensive and not easy to afford by average income people.

v) Affordability of other competitors for the solar thermal technology

In domestic small scale applications, there are many alternatives to heat water such as instantaneous water heaters, gas water heaters and electrical water heaters. There prices are much lower than solar water heaters. It can be as low as one third to one tenth. Low income people almost think about initial cost to pay without giving operation cost same consideration. Although economic feasibility shows better advantage for solar water heaters over the other alternatives, many customers still go for conventional systems. Moreover, instantaneous heaters can give water all the time to the point of use without losses of water

2.5. Identified measures

The technology may become affordable through a combination of the following economic and financial measures and non- financial measures.

2.5.1. Economic measures

i) Low costs for solar thermal technology will be realized by encouraging the private sector to establish qualified industries locally. Cupper flat plate collectors may provide better echo among customers due to the higher efficiency in comparison to the current steel industries. Vaccum tube industries also has applications and availability of local industries will encourage customer to buy them due to the availability of spare parts.

ii) Considering that solar technologies are exempted from sales tax, exemption from income tax will reduce initial costs.

iii) Providing subsidies by seeking international environmental programs and other aids that have such initiatives. Revolving funds is a successful experience in Jordan but still limited to certain communities. It is necessary to promote this experience among Jordan

iv) Government may guarantee banking loans or cooperate with local banks to reduce interest rate;

v) Encourage insurance companies to cover large scale solar thermal power stations.

2.5.2. Non-economic measures

i) It is expected that establishment of focused training programmes (including both university and vocational training institutions in Jordan) will result in existence of critical mass of technicians in the country to undertake activities such as installation, maintenance and operation of systems. This is likely to result in low costs for installation, repair and operation.

ii) Enforcement of standards will lead to better quality of systems and lower maintenance requirements. This will lead to high system reliability and better echo among customers;

iii) Effective awareness programs that educate customers about the real feasibility of the solar technologies and its real maturity will lead to better diffusion of the technology.

2.6. Linkages of the Barriers Identified

The three technologies have solar in common and thus share many technicalities. However, the table below (Table 4) briefs the linkages among barriers

Table 4: Barriers linkages between the three technologies

Category	**Technologies**
Economic and financial barriers	Initial cost may not be affordable to users of the three technologies. Loans are confronted by the local high interest rate
Non economic barriers	• Users have little or no information on the techno-economic feasibility of the systems • Lack of technical capacities that needs training program • Lack of enforcement for the laws and regulations • Few manufacturers

2.7. Enabling Framework for Overcoming the Barriers in the Three Technologies

The government has issued and implemented several regulations that may be considered as the prevailing enabling environment, which is elaborated as follows:

Jordan Renewable Energy (RE) Policy/Strategy Targets

According to the country's national energy strategy and master plan, the following targets were set:

- Promoting RE to contribute 7% in the primary energy mix in 2015, and 10% in 2020;

- Main Projects to be developed either through Competitive Bidding, or Direct Proposal Submissions to reach these targets include:

- 1200 MW Wind Energy
- 600 MW Solar Energy
- 50 MW Waste-to-Energy

RE and Energy Efficiency (EE) Law:

The Law was issued in April 2012, allowing Direct Proposal Submissions of projects for generating electricity and connecting to the grid. Currently, contracts four projects of 200 MW total have been signed.

By-laws and Regulations for Investment:

The by-laws and regulations related to RE projects for electricity generation were also issued, mainly:

- The Reference Price List, which includes the indicative prices for each type of renewable source;
- Sale of Electrical Energy Generated from Small RE Systems (Net Metering – Roof-Tops);
- Connecting RE Facility to Distribution Grid.

These clear regulations has paved the way for smoother and easier dissemination of systems among the country.

Energy Efficiency (EE) By-law:

- Issued on 14 November 2012;
- Solar water heaters were becoming mandatory as of April 2013 for new buildings;
- Energy Service Companies (ESCOs) market to be regulated;
- Labeling is mandatory to all electrical appliances in the country.
  As a result, penetration of solar water heaters is increasing.

Tax Exemptions By-law:

- Exempting all RE and EE systems and equipment from Sales Tax and Custom duties;

- All RE projects shall enjoy the tax exemptions applicable to Conventional IPP projects.

Ongoing Grid Reinforcement Plans by NEPCO:

The so-called “Green Corridor” transmission line is under development to absorb new renewable power generated. This will pave the way for more PV solar applications.

Jordan Renewable Energy and Energy Efficiency Fund (JREEEF):

This fund was established in accordance with Articles of the RE & EE Law aiming to:

- Provide incentives and financial support for RE and EE measures, studies and projects;
- Promote the use of RE and EE in Jordan;
- Encourage private-sector investment in RE and EE projects and activities.

The idea of discussing the enabling environment is to understand the elements that affect the market chain for solar technologies and thus make it possible to examine the powers and interests that drive change. The following are the additionally needed complimentary measures for the three solar technologies to work side-by-side with the government’s currently prevailing enabling environment so that together such integrated measures will serve to overcome such barriers and assist wide dissemination and deployment of the three priority technologies:

i) Regulations. There is big need to review regulations based on inputs from suppliers and manufacturers. Long process of approvals need to be investigated and reflected in the regulations. Enforcement of certain regulations is a milestone in ensuring long-term operation of systems and better reputation of systems;
ii) Standards: There is still big need to enforce national standards for solar technologies and to prepare further standards based on international experiences and best industry practices;
iii) Capacity building. There is evident high need to strengthen capacity building for solar technologies specially in the proper design, operation and maintenance;
iv) Green funds: Such kind of funds need to be further augmented, which will serve as financial mechanisms to support development and diffusion of solar systems and enhancing its affordability by customers;
v) Awareness: This can be resolved by implementing real feasibility studies that shows the real economic and environmental benefits of the technology based on life-cycle cost analysis. Examples from previous installations will show the maturity of the systems and thus convey a clear message to customers about the reliability of these new technologies;
vi) Initial cost: The effect of the high initial cost of solar technologies can be mitigated by setting up of local assembling and manufacturing industries for certain parts and systems. Moreover, enhancing R&D specially in solar-thermal systems may improve system efficiency and thus improve its economy;
vii) Subsidies: Although VAT is removed, removing income tax on solar technologies is a good tool of subsidies; and
viii) Incentives: To encourage electricity companies in Jordan some kind of incentives is needed

3. TRANSPORT SECTOR

3.1. Preliminary Targets for Technology Transfer and Diffusion

The following could be considered as specific targets for mitigation technologies' transfer and diffusion in the transport sector in Jordan:

Bus Rapid Transit

The Bus Rapid Transit (BRT) technology is non-market publicly provided technology, because it is mostly managed and implemented by the governments. In general the bulk of barriers in the sector is related to high cost of implementation in addition to poor coordination between stakeholders and empowering related policies. According to Jordan's Third Competiveness Report[10], Amman as a capital city has one of the lowest public transportation mode share ratios in the world, at 11.1%. Greater Amman Municipality (GAM) in Jordan is planning[11] to implement a BRT system that will be the city's first bus rapid transit system, while Ministry of Transport (MoT) is responsible for the Amman – Zarqa BRT, in which premium; high-capacity buses will run on exclusive and completely segregated lanes. The system will include development and design of stops, stations, and passenger information, vehicle specifications, interchanges and terminals, and buses running on a frequency possibly as low as 3 minutes along Amman's busiest corridors.

The BRT corridors in Jordan 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.

Pedestrian Infrastructure

The pedestrian infrastructure in Jordan does not yet receive adequate attention in transport planning; several walkways are packed with trees and bushes, many are not wide enough for pedestrians, and many streets don't have pedestrian walkways in the first place. Thus, targets for Pedestrian Infrastructure technology can be summarized as the following:

- Fostering pedestrian infrastructure to receive adequate attention in transport planning;
- Rehabilitating walkways and developing new directives to regulate the design and
- Construction of walkways according to best industry and international practices so walkways are wide enough for pedestrians and serve to achieve objectives they were designed upon.

Such issue can be a possible cause for the fancy *Abdoun Bridge* example highlighted in the transport sector's chapter, as it is considered quite luxurious, yet lacking the pedestrian walkway. Among of the non-financial barriers to implementation are the legal and regulatory barriers, as there exists a policy gap for the enforcement of sidewalk regulations, as well as the regulations that affects the pedestrian behaviors. Infrastructure regulations in Jordan are not yet according to international standards, which must be changed in order to enforce infrastructural development.

Ticketing System

The managing tool of the ticketing system technology is not fully mature to be implemented in Jordan because the infrastructure of the public transportation is not well developed and there are huge gaps in integrating the diverse of the public transportation modes. Thus, targets for Pedestrian Infrastructure technology can be summarized as the following:

- Developing advanced management systems for the public transportation in Jordan;
- Decreasing vulnerability of infrastructure for the public transportation; and
- Diversifying modes of public transportation (more than Buses, White Taxies, and Yellow Taxies).

The ticketing system does not need a high investment as other technologies because it does not need an infrastructure. It is counted as a management tool for the public transportation that eases the payments and cash circulation between the user, operator and the government. But here one can find the main barrier which is the lack of trust between the operator and the government. It will be so hard for the operator to be monitored by the government for the revenue of operating the public transport.

3.2. Barrier Analysis and Possible Enabling Measures for BRT Technology

To identify barriers and outline solutions (measures or incentives) for BRT technology and the other two-transport sector's technologies, problem trees and solution trees exercises were used (Annex 4). The results of in depth assessments of barriers facing such technologies and most viable measures are elaborated below.

3.2.1. General description of BRT

BRT has increasingly been used to provide a faster, higher capacity bus service. 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 means of transportation. Such a clean vehicle technology contributes to improve the health of the passengers and the urban population at large. 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[12]. 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[13]. Also, having the bus station platform level with the bus floor is an important way to reduce boarding and alighting times per passenger. Moreover, it could be integrated with other public transport, which includes physical transfer points, an integrated fare system and integrated information. Worldwide BRTs 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.

It is assumed that by 2017, BRT systems will be one of the main factors of sustainable urban transport in Jordan capturing a share of 25% of all transport needs[14]. 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, and signal priority.

The Ministry of Transport in Jordan (MoT) has already started implementing the infrastructure for this technology in the main streets in Amman. However, some important barriers face this new technology to be tried for the first time in Jordan. The sections below elaborate on financial/economic and non economic barriers tied to the technology.

3.2.2. Identification of barriers for BRT technology

Identification of barriers of this technology (and the other two technologies of the transport sector elaborated below) encompassed conducting extensive literature review of policy papers and other pertinent reports and documents mainly those developed by aid agencies in Jordan as the later are more involved in mega transport projects in Jordan. The list of reviewed references included but not limited to:

- Jordan's Third Competitiveness Report: The Transportation Sector, 2010-2011;
- Jordan Transport Sector Policy Paper, 2012;
- National Climate Change Policy of Jordan 2013-2020;
- Third National Communication Report to UNFCCC, 2014;
- Jordan Long-term National Transport Strategy and Action Plan 2014,;

Moreover, identification of barriers also comprised desk studies that included economic and other relevant assessments of the three technologies; consultations with eminent experts in the sector and other stakeholders, and most importantly organizing dedicated stakeholder involvement and consultation workshop inviting stakeholders from the government and private sector (Figure 4).

The BRT technology is a non-market publicly provided technology as most of transport technologies, because it is mostly managed and implemented by the government. In-depth assessments of barriers facing the technology involving sector's active stakeholders, who reviewed the technology's factsheet prior to conducting the assessment, revealed the following lists of barriers which need to be tapped in order to avoid traffic, pollution, accidents, and improve public trust in transport sector institutions in the country.

Figure 4: A photo of Transport Sector's stakeholders participated in the BA&EF consultation workshop held from May 10-11, 2016.

3.2.2.1. Economic and financial barriers

- High investment cost. The potential of resources is one of the main barriers because of high initial cost with low interest of international sponsors to cover it. The precise characteristics of each BRT strongly depend, among others, on the local market, the operational and physical application environment and available resources. Estimates for investment cost for BRT systems vary widely depending on the required capacity, length of roads to be constructed, the number of stations, type of buses, control systems etc. 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[15], with most existing BRTs in developing countries in the lower part of this range[16]. These figures are substantially lower than those for rail-based systems, which cost approximately $ 50 million per km[17].

- In case of minor changes in the roads system, the investments range from $1.35 up to $ 3.5 million/km, or can increase to $4.8 - 8.2 million/km[18].
- The BRT project cost in Jordan is around 68 million JD, and the project is expected to be financed as a grant from the Kuwaiti Fund for Arab Economic Development.
- Needs subsidies to incentivize the operator. This is heavily due to the private ownership for the overwhelming majority of busses fleets in Jordan, high cost of fuel, and high cost of public transportation.

3.2.2.2. Non-financial barriers

The non-financial barriers of the BRT technology in Jordan are categorized into the following groups:

Legal and Regulatory Barriers

- The absence of a land use planning regulatory lead to delay in forming and implementing sector-related decisions. Some of the main causes of such barrier are the rapid population growth, the critical political circumstances in the region, lack of long term planning and disintegration between building and transportation infrastructure planning, and lack of information base. The aforementioned causes lead to a weak system of planning and an increase in the percentage of accidents, GHG emissions, traffic jams, difficulty in mobility, and thus increased rates of interruption for economic activities, which ultimately lead to increased rates of poverty.
- Political instability and demographic implications caused by increasing rates of conflict in the neighboring countries and accompanying refuge waves fleeing to Jordan.

Technical Barriers

- Limited technical knowledge of the technology. This is mainly because the technology is very new to the country and still needs some time to build technical knowledge platforms.
- BRT's main drawback compared to other urban transport systems is its demand for urban space. Thus, considerable acquisition of street spaces and infrastructure changes is required. This may cause more congestions on poorly planned main streets where future development plans were not anticipated in historical plans.
- Limitations of regularity for new development expansions and number of professional companies for maintenance are other forms of technical barriers.

Network Barriers

- Conflict of interests between the stakeholders
- varying standards for stakeholders. This highlights the need for strengthening coordination among transport sector institutions.

Institutional and Organizational Barriers

- Limited knowledge on the technology and mismanagement seem to act as institutional barriers that are a result of the fact that the BRT technology is new and there is no previous experience of such

technology in Jordan. There is also no one certain institution responsible of BRT implementation, which means that its implementation requires coordinated management as well as avoidance of technical barriers.

Human Skills Barriers

- Limited human capacities and professional knowledge in this technology;

Social, Culture and Behavioral Barriers

- Technology is new to Jordanian residents who are not socially and culturally prepared for it yet, as they have a car dependent culture. This is causing a lot or rumors about rationale of deploying such technology in the country;

Information and Awareness Barriers

- Few number of awareness programs and campaigns specially those targeting rumors about the rationale to deploy technology in Jordan;
- Limitations in base lines for information databases;

3.2.3. Identified Measures for BRT technology

The development and implementation of the BRT was conceived as part of a comprehensive development plan to address the growing mobility problems in the Jordanian governorates with high population. The measures of enhancing the usage of BRT in public transport development plans include the following elements:

3.2.3.1. Financial measures

- Lowering investment cost.
- Introducing incentives to increase the interest of international sponsors to cover the cost of such expensive technology.
- provide subsidies to incentivize the operator to minimize the impact of the private ownership for the overwhelming majority of busses fleets in Jordan as related to high cost of fuel, and high cost of public transportation.

3.2.3.2. Non-financial measures

Legal and Regulatory Measures

- A strategic rehabilitation plan for the main streets. Breaking down the barriers related to the BRT technology requires combined efforts on many levels. For example, for the legal and regulatory barriers, forming a strategic rehabilitation plan for the main streets that will contain a lane for the BRT, accelerating implementation, as well as transparency would be some of the suggested measures to breaking these barriers.
- Promoting and advocating for developing proper transport-oriented land use planning regulatory which aims at minimizing delay in forming and implementing sector-related decisions. This will alleviate

impacts of rapid population growth, critical political circumstances in the region, lack of long term planning and disintegration between building and transportation infrastructure planning, and lack of information base. The aforementioned measure should lead to a holistic land-use planning regime which will lead to decreased percentages of accidents, GHG emissions, traffic jams, difficulty in mobility, and thus increased rates of interruption for economic activities, which ultimately lead to increased rates of poverty.

- Developing plans that take political instability and demographic implications caused by increasing rates of conflict in the neighboring countries and accompanying refuge waves fleeing to Jordan, into consideration.

Technical Measures:

- Breaking technical barriers would require a strategic rehabilitation plan, as well as designing new streets that encourage BRT, a suitable contractor for maintenance operations, and strict contracts with operators.
- Accelerate building technical knowledge of the technology to expedite the novelty impacts of deploying such technology in Jordan is;
- Well-developed plans for acquisition of street spaces and infrastructure changes. This is important to minimize impacts of congestions on poorly planned main streets where future development plans were not anticipated in historical plans.
- Increased number of regularity for new development expansions;
- Promoting and empowering more professional companies for operation and maintenance capacity in this technology;
- Improving existing public transport services (i.e., for current users). This includes increasing the number of feeder buses, implementing new specifications for buses (air conditioning, easy entry, electronic payment system), and installing new bus shelters and street furniture;
- Developing and implementing the core network, which consists of BRT and feeder buses along key corridors to provide alternative to cars.

Network Measures

- Network barriers would need institutionalized roles among stakeholders, involving the private sector for operation, having a specific representative institution that will be responsible for the operation, and rehabilitating the current public transport modes that used to operate the BRT streets to play the role of bus feeders;
- Removing potential conflict of interests between the stakeholders;
- Creating a common platform of standards for stakeholders. This highlights the need for strengthening coordination among transport sector institutions;

Institutional and Organizational Measures

- Creating an effective institutional environment for the implementation of such technology through advancing new management systems to minimize the novelty effect of BRT technology in Jordan. This is highly needed due to no previous experience of such technology in Jordan.
- A one coordination entity is needed to be in charge of coordination of BRT implementation in the country, so that its implementation is well coordinated to decrease impacts of technical barriers.
- Hiring a representative institution responsible for operating the BRT, along with professional experts, and a private professional contractor to build capacities of technical staff will be important for overcoming such institutional organizational as well as human skills barriers.

Human Skills Measures

- Build human capacities and professional knowledge in this technology;

Social, Culture and Behavioral Measures

- Duplicate awareness and information programs and campaigns to raise awareness of advantages of such technology so that citizens are more socially and culturally prepared to accept it. This will remove the rumors about rationale of deploying such technology in the country;
- Use the current bus modes and operators to integrate the public transportation involving BRT scheme in a practical manner, setting a new full plan for the public transportation lines as a whole, accompanied with a huge awareness campaign to encourage people to use public transportation and subsidizing the cost of public transportation to encourage its usage.

Information and Awareness Measures

- Increased number of awareness programs and campaigns specially those targeting rumors about the rationale to deploy technology in Jordan;
- Increased number of base lines for information databases;
- Media campaign to encourage people to use public transportation, which could be done by uploading information to a specific website with wide range access and updating it regularly.

3.3. Barrier Analysis and Possible Enabling Measures for Pedestrians Infrastructure

3.3.1. General description of Pedestrian Infrastructure technology

The pedestrian infrastructure in Jordan doesn't yet receive adequate attention in transport planning. Several walkways are packed with trees and bushes, many are not wide enough for pedestrians, and many streets do not have pedestrian walkways in the first place. Such phenomena are not only true for poor and weak infrastructure parts of the country but also applicable to fancy neighborhoods of Amman. One of the major and most recent bridges built in the high-end part of the city Amman, the '*Abdoun Bridge'*, lacks a pedestrian walkway, highlighting the fact that the concept of including pedestrian walkways is missing from transport mentality and planning. Thus, there lies the need for transport master plans that integrate all modes of transport, including walking, in planning processes.

Implementing pedestrian walkways has several advantages, firstly, walking doesn't contribute to greenhouse gas emissions. A walking trip of 2 kilometers (a very feasible distance) reduces greenhouse gas emissions by 419 grams of CO_2 (equivalent) if it replaces a car trip[19]. Walking also promotes physical and mental health. It reduces or prevents obesity, cardio-vascular disease, diabetes, and depression and sleep disorders. It seems to have more advantages than disadvantages, and is easy and non-costly to apply, without imposing any financial risks on the government. Such details are to be discussed further in the following parts of this chapter.

3.3.2. Identification of barriers for Pedestrian Infrastructure technology

3.3.2.1. Economic and financial barriers

- Extra cost. Capital costs for implementing pedestrian walkways can 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 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.
- Although the costs are quite low compared to other transportation infrastructure, walkways do not seem to take a major part in governmental financing priorities; this in turn forms a financial barrier for their implementation, since they are not enforced by the government. Such issue can be a possible cause for the Abdoun bridge example highlighted above, as it is considered quite luxurious, yet lacking the pedestrian walkway.

3.3.2.2. Non-financial barriers

Legal and Regulatory Barriers

- Policy gap for the enforcement of sidewalk regulations, as well as the regulations that affect pedestrian behavior. There is high need for a regulatory body responsible for assuring correct implementation of walkways. One major barrier to implementing walkways is the need for law enforcement for walkway regulations;
- Infrastructure regulations in Jordan are not yet in accordance with international standards that is related to the width, height and used materials, which must be changed in order to enforce infrastructural development, while the implementation of the sidewalks are usually done by private contractors with the building owners and the Great Amman Municipality should monitor it after getting done.
- Additionally, raw materials used in infrastructure must be standardized and enforced on infrastructure contracting companies; meanwhile existing walkways can be rehabilitated in order to match pedestrian needs. These could also be considered technical barriers as well.
- Corruption related to supervision. There is still weak enforcement of the relevant regulations due to illegal deals between involved supervisors of authorities in charge and contractors;

Technical Barriers

- No standardized materials used in infrastructure and weak enforcement on infrastructure contracting companies;

Human Skills Barriers

- Lack of specialists in such practice as well as absence of qualified monitoring (supervision) staff. The lack of specialists is a result of hiring unqualified workforce by the government for the monitoring and evaluation positions who underestimate the importance of implementing walkways;

Social, Culture and Behavioral Barriers

- Existing culture that does not encourage walking to destinations, where citizens prefer using vehicles even to nearby destinations. This culture was built because there was no motivators for waking, such as suitable walkways without any obstacles plus that it becomes very common to own a car by each one who have license. One of the causes of such barrier is missing environmental and social impact assessments when implementing roads and walkways projects.
- Absence of activities needed to be done on bringing about a more positive outlook for citizens on using walkways and encouraging this behavior such as limited programs on raising awareness on the advantages of walking, and the harm caused from heavy usage of vehicles on health and environment.

Information and Awareness Barriers

- Limited amount of awareness programs and campaigns targeting changing existing culture that does not encourage walking to destinations, where citizens prefer using vehicles even to nearby destinations. The new culture of walking could be motivated by promoting suitable walkways that has no obstacles and wide enough. Some activities still needed to be done on bringing about a more positive outlook for citizens on using walkways and encouraging this behavior targeting advantages of walking, and the harm caused from heavy usage of vehicles on health and environment.
- Absence of materials encouraging walkways in environmental and social impact assessments when implementing roads and walkways projects.

3.3.3. Identified measures for Pedestrian Infrastructure technology

3.3.3.1. Financial measures

- Reducing the extra cost by imposing cost share on buildings owners to rehabilitate the walkways to have the walkway abide with set standards. But in general, walkways cost only a small fraction of the cost of roads, and they can even be created with paint on pavement.
- Walkways should become a major part in governmental financing priorities; this in turn will remove the financial barrier for their implementation.

3.3.3.2. Non-financial measures

Legal and Regulatory Measures

- Developing a national policy for the enforcement of sidewalk regulations, as well as the regulations that affect pedestrian behavior. A regulatory body should be established responsible for assuring correct implementation of walkways. This measure should impose law enforcement for walkway regulations. The pedestrian infrastructure for the government of Jordan should become a priority to give it a share of

their development plans and strategies to develop the walkways, with emphasis on financial and non-financial share;

- Aligning infrastructure regulations in Jordan with international standards that is related to the width, height and used materials, which must be changed in order to enforce infrastructural development. This requires standardizing and enforcing raw materials used in infrastructure on infrastructure contracting companies; and rehabilitating existing walkways in order to match pedestrian needs against such standards;
- Designing a walkway building code based on the international standards and enforcing its implementation, enforcing the factories to produce the sidewalks raw materials that follow the standards, and not allowing for usage of unsuitable raw materials, and setting a strategic plan to rehabilitate old and unorganized sidewalks, all of which make up measures which may overcome technical barriers as well;
- Combating corruption related to supervision through enforcement of the relevant regulations and preventing illegal deals between involved supervisors of authorities in charge and contractors;
- Establishment of a special department that monitors all new buildings and contracting companies with strong law enforcement, setting a special law for pedestrian behavior, as well as imposing sanctions on the entities who break the pedestrian law. Setting tough sanctions on individuals who allow contractors to build sidewalks which are not according to standards can help overcome institutional and organizational barriers as well.

Technical Measures

- Standardized materials should be used in infrastructure accompanied by strong enforcement on infrastructure contracting companies;

Human Skills Measures

- Building capacities of more specialists in such practice as well as providing more qualified monitoring (supervision) staff.

Social, Culture and Behavioral Measures

- Developing behavioral and culture change programs that encourage walking to destinations targeting citizens preferring to use vehicles. This new walking culture would be empowered through advancing new motivators for waking, such as suitable walkways without any obstacles plus. To that end environmental and social impact assessments could help when implementing roads and walkways projects.
- More activities on bringing about a more positive outlook for citizens on using walkways and encouraging this behavior such as extensive programs on raising awareness on the advantages of walking, and the advantages caused from minimal usage of vehicles on health and environment.

Information and Awareness Measures

- Increased amount of awareness programs and campaigns targeting changing existing culture that encourage walking to destinations, specially for citizens preferring using vehicles. The new culture of

walking could be motivated by promoting suitable walkways that has no obstacles and wide enough. More activities are needed to be done on bringing about a more positive outlook for citizens on using walkways and encouraging this behavior targeting advantages of walking, and the harm caused from heavy usage of vehicles on health and environment.

- Inclusion of materials encouraging walkways in environmental and social impact assessments when implementing roads and walkways projects.
- Organizing awareness campaigns for contractors, and pedestrians to raise their awareness on the new pedestrian regulations, as well as assessing community needs for sidewalks prior to construction, and designing them on that basis would be major contributions to overcoming social, cultural and behavioral barriers as well. Finally, organizing awareness campaigns after setting the needed regulations and standards can help in breaking information and awareness barriers.

3.4. Barrier Analysis and Possible Enabling Measures for Ticketing System

3.4.1. General description of Ticketing System

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.

3.4.2. Identification of barriers for Ticketing System technology

3.4.2.1. Economic and financial barriers

- Absence of a centrally-regulated one financial system that controls all the payments for the public transportation;
- Financial mistrust between regulator and operator. The ticketing system does not need high investment as other technologies because it does not need to build a new infrastructure. It is counted as a management tool for the public transportation that ease the payments and cash circulation between the user, operator and the government. But here one can find the main barrier which is the lack of trust between the operator and the government. It will be so hard for the operator to be monitored by the government for the revenue of operating the public transport. Such new system will stop the financial independency of public transportation means operators including micro and large busses as well as white taxies. Such new system is expected to be confronted by such private operators.

3.4.2.2. Non-financial barriers

Legal and Regulatory Barriers

- The regulatory infrastructure for the ticketing system technology is not fully mature to be implemented in Jordan because the current public transportation system is not well developed and there are huge gaps missing in integrating the diverse of the public transportation modes.
- New regulations are required to address the existing system, which is wholly based on direct payment cash patterns. The new regulation will ease managing payments system for public transport.

Technical Barriers

- Current inherited technical modalities of running the public transport system, such as absence of mandatory time-regulated bus stops and stations that could be supplied with ticket recharging machine, integration between different modes, and bus lane violations. Such technical barriers that come in the way of the ticketing system technology lie behind the old, unorganized network and infrastructure for public transport, which was implemented without specific urban planning. Such technical barriers lead to traffic jams, the avoidance of using public transport by the public, and problems with the cash controller
- Absence of an integrated system for payments

Network Barriers

- Operators lobby network effect of ability to create a united opposition to any public transport system that is against their interests such as ticketing system.

Institutional and Organizational Barriers

- Individual citizens operating their own public transportation vehicles or fleets due to current system of privatization. This implies no restrictions or control on payment systems;
- Huge number of individual operators; thus huge number of management entities representing many operators which are hard to coordinate with wholly;

Human Skills Barriers

- Different system operators require systematic training on a unified payment system that will require them to be controlled under;
- Difficulties for unified training programs due to huge number of individual operators;

Social, Culture and Behavioral Barriers

- Conflict of interest with cash controller (individuals collecting fees at public transportation vehicles) who will lose their jobs if ticketing system is deployed;
- Habits of people to pay in cash due to their accustomed financial transaction schemes;

Information and Awareness Barriers

- Needs to develop well informative awareness campaigns on advantages of such new practice;

Market Barriers

- Varying ticket prices mainly caused by the weakly organized and controlled public transport network of busses and taxies fleets at varying public transport modes, which in turn causing unfair payments in different transportation modes.

3.4.3. Identified Measures for Ticketing technology

3.4.3.1. Economic and financial measures

- Creation of a centrally-regulated one financial system that controls all the payments for the public transportation.
- The new system should remove financial mistrust between regulator and operator such as the new system is counted as a management tool for the public transportation that ease the payments and cash circulation between the user, operator and the government. The new system should allow for the operator to be monitored by the government for the revenue of operating the public transport. But the new system should not harm financial situation of public transportation means operators including micro and large busses as well as white taxies;
- Incentivizing the current operators to use this technology and create a joint committee of regulator and operators to monitor the financial circulation between the users, operators and the government;
- Incentivizing the users of the tickets;

3.4.3.2. Non-financial Measures

Legal and Regulatory Measures

- The regulatory infrastructure for the ticketing system technology should become fully mature to be implemented in Jordan through developing the current public transportation system and removing the huge gaps preventing integrating the diverse public transportation modes under one holistic ticketing system. This system promote for integration between all public transportation service and lines;
- New regulations should be advanced to address the existing system, which is wholly based on direct payment cash patterns. The new regulation will enforce all transport operators to use one ticketing system in payments. This will ease managing payments system for public transport;
- Restructuring the payments for the public transport in a fair manner to prevent unjust payments;

Technical Measures

- New changes targeting establishing an integrated system for payment aiming at enhancing inherited technical modalities of running the public transport system, such as establishing mandatory time-regulated bus stops and stations that could be supplied with ticket recharging machine, integration between different modes, and minimizing bus lane violations. Such technical changes will lead to removing technical barriers that come in the way of the ticketing system technology which will lead in turn to modern and organized network and infrastructure for public transport, implemented through a proper urban-planning. Such technical changes will also lead to minimizing traffic jams, encouraging using public transport by the public, and eliminating with the cash collectors (controllers);

- Providing and easy to access, widely available, and creative means (such as mobile-based, bank cards-based, etc) to recharge the public transport tickets;

Network Measures

- Crate alliance with the operators to prevent their lobby effect against the ticketing system;

Institutional and Organizational Measures

- Develop proper institutional and operational systems to integrate engagement of individual citizens operating their own public transportation vehicles or fleets under the new ticketing system;
- Hiring expert companies to build the network and needed tools and equipment to implement this technology;
- Restructuring the payments for the public transport in a fair manner to prevent unjust payments;

Human Skills Measures

- Develop systematic training and capacity building programs for system operators on a unified payment system;

Social, Culture and Behavioral Measures

- Develop social impact studies to solve issue of conflict of interest with cash controller (individuals collecting fees at public transportation vehicles) so that not to cause them to lose their jobs if ticketing system is deployed;
- Develop programs directed towards changing habits of people used to pay in cash;

Information and Awareness Measures

- Develop well informative awareness campaigns on advantages of such new practice;

3.5. Linkages of the barriers identified

It was clear that the infrastructure for the public transportation as a common barrier is not well developed and there is several major barriers to step forward to get a well developed and systemized public transportation in Jordan. First of all, the governmental institutions must give more attention to the transport sector as one of the main development indicators that needs a lot of effort in breaking the main barriers. For example, if the public transportation was considered in the urban planning with regard to infrastructure such, as the width of the streets, the built environment, special spaces for the walkways and other standards, several technologies would have been easy to be implemented and deployed. The main issue in Jordan that prevents people from using walkable locality is the absence of good infrastructure for pedestrians which in turn inhibits governments to set special regulations that organize pedestrian behaviors. Consequently, by providing suitable pedestrian infrastructure, governments will be able to overcome several barriers, such as setting regulations related to pedestrian behaviors and develop the pedestrian infrastructure. Such technical barrier of weak infrastructure is also affecting fast deployment of other transport sectors' technologies such as BRT.

Since many of the technologies are interlinked together especially by the main causes and effects, one can identify the barriers' measures altogether. For example, removing information and awareness barriers can eliminate some of the social, cultural and behavioral barriers, which in turn leads to the openness of policy makers towards providing the suitable legal and regulatory framework that encourages the implementation of technologies of the sector. The current regulation that manages public transportation has a big gap between the governmental stakeholders and the private operators (individuals and companies). In turn, this barrier limits any new technology implementation such as the ticketing system and the BRT from being implemented, and carries out more barriers to the ground with emphasis on barrier rated to coordinated action. So by solving this issue and coming up with new regulations, this will stop the individual ownership of the public transportation modes and will organize the payments from the users to the operators and from the operators to the government.

BRT is predicted to be one of the best technologies to increase the use of public transport. However, it needs to be integrated with the current public transport modes. The BRT corridors should also not be designed in isolation but it must be incorporated into an integrated public transport network by rearranging the full public transportation routes that includes the pedestrians infrastructure and the ticketing system. To that end, all related infrastructure barriers should be solved. The technology users should get from their doorstep to their workplace passing by several transport technologies. In order to avoid any networks or cultural barriers it should utilize the current operators as feeders. Such 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 set and wait for the bus and offer a seamless travel experience.

3.6. Enabling framework for overcoming the barriers in the three technologies

Transport Sector is a precondition for economic development and it is the second greenhouse gas emitter with the percentage of 16.4% from the total energy emissions in Jordan[20]. It cannot by itself create growth and reduce greenhouse gas emissions but there will be no sustainable development if good connections are absent within the country, the region and the rest of the world. A well-developed transport network equipped with proper regulatory system can positively affect the country's productivity and competitiveness that, in the context of a global economy, is a potential leverage in increasing international trade. Transport mods needs to be continuously adapted to meet the changes occurring in transport demand and travel behavior and also to be developed with less emission using new technologies. If this is not the case, the result will be an increasing number of negative effects like costs increase, congestion, lack of reliability, pollution, etc. where the transport sector, instead of playing its major positive role in the growth of the economy, will become an obstacle to the country's development.

The primary enabling environment that transport in Jordan has secure in the near future can be articulated throw following a set of pillars as follows:

- **Policy and Regulatory**

  Developing a national policy for the enforcement of GHGs mitigation-oriented technologies, which are based on proper holistic landuse planning promoting new regulations for sidewalk

and pedestrian behaviour while addressing mega projects such as BRTs aiming at minimizing transport congestion in the country. A regulatory body should be established responsible for assuring correct implementation of such integrated system. This measure should impose law enforcement for tied regulations. The pedestrian infrastructure for the government of Jordan, for instance, should become a priority to give it a share of their development plans and strategies to develop the walkways, with emphasis on financial and non-financial shares.

More focus should be given to public transportation regulations to be a suitable alternative than using private cars. This could be the best option to reduce the number of private vehicles.

- **Institutional Structure**

  The quite complex transport sector's institutional structure in Jordan needs more development. It is fairly evident that the proper implementation of a transport strategy requires a clear and efficient institutional set-up at national level where: (i) responsibilities are soundly defined, (ii) monitoring is in place and (iii) all actors operate in a coordinated way, this could be occur by giving the authority for one central governmental institution that will be responsible of developing the public transportation throw collecting data, planning, monitoring, evaluating and the most important point is to enforce the regulations.

- **Infrastructure**

  Transportation and pedestrians infrastructure in Jordan needs to be rehabilitated to be able to absorb the high increase of private vehicles and to maximise the incentives of using public transportation that will promote using the public transport instead of using private cars. This will also promote walking habits. The poor organized public transportation guided the people in Jordan to not use it, which impacts the high increase of the private transportation in the country. Focusing on developing the infrastructure to be able to absorb the new technologies of public transportation such as the Bus Rapid Transit and the pedestrians' infrastructure will help to solve most of the transport barriers.

- **Funding**

  There is a general problem of scarcity of financial resources due to the economic crisis mainly affecting western world countries. The implication for Jordan is twofold: less funds are available and a difficulty for the government to provide sovereign guarantee to donors willing to fund infrastructure projects in Jordan. Support from international funders and Public Private Partnership (PPP) could partially overcome these financial constraints.

4. WATER SECTOR

4.1. Preliminary Targets for Water Sector's Technology Transfer and Diffusion

For the water sector, the top three technologies under investigation are: *roof-top rainwater harvesting*; *desalination/brackish water treatment and re-use*; and e*mpowerment and expansion of Water Users Associations (WUAs)*.

The roof-top rainwater harvesting was classified as a consumer market technology and the following preliminary targets for transfer and diffusion of such technology were set: (i) to take advantage of a simple practice of roof-top rain water harvesting, which could be utilized in arid and semi-arid ecosystems (like Jordan. In such geographic regions, 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. This is particularly relevant in arid and semi-arid regions, where the little rainfall received is usually very intense and often seasonal. The target is however, to collect rainwater using appropriate infrastructure and national expertise; (ii) increase the volume of freshwater available for human use in a country considered one of the top three water-scare countries in the World.

The *desalination/brackish water treatment and re-use* was classified both as a consumer market technology if procured by individuals, mainly farmers at Jordan Valley and industry, as well as a capital good if procured by the governmental institutions and water utilities. For such technology, the following preliminary targets for transfer and diffusion of the technology were set: (i) to investigate the potential of augmenting and accelerating desalination in Jordan, i.e., to maximize the breakthrough of this technology in Jordan since to date the desalination of either seawater or brackish water in Jordan has been very limited; (ii) to assess such technology in light of the fact that purification of seawater/brackish water is expensive, energy intensive and often has large adverse impacts on ecosystems, and (iii) particularly to assess the cost of energy to desalination in Jordan particularly since Jordan, unlike many of its Arab neighbors, has virtually no indigenous energy sources.

The e*mpowerment and expansion of WUAs* was classified as other non-market technology. for such technology the following preliminary targets for transfer and diffusion of the technology were set: (i) to assess the potential of augmenting and widening experience of Jordan in transferring management of irrigation systems from government agencies to water users associations (WUAs) or other private sector entities. This is aiming at improving the efficiency and performance of water resources management in the country to cope with the issue of water scarcity and problems associated with climate change; (ii) to assess the current status of the legal framework of WUAs in Jordan. There still is a widespread need for a clearer legal status, a proper governing legislation and water rights given to WUAs and farmers. Without a clear legal status, WUAs cannot operate properly because they do not know the extent as well as the authentic (Jordan Valley Authority vs. Jordan Cooperatives Corporation) supervisor of their responsibilities. 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 including retail

distribution and network irrigation maintenance to the WUAs. The said law will allow JVA to provide the legal umbrella for the establishment and supervision of WUAs. This will also set the legal requirements for the WUAs to collect fees from farmers and thus 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; and (iii) to assess the crucial financial sustainability aspects of WUAs and potential measures of attaining economic independency.

4.2. Barrier Analysis and Possible Enabling Measures for Roof-top Rainwater Harvesting

4.2.1. General description of roof-top rainwater harvesting

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[21]. 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. In this project, all descriptions of such technology including information elaborated in the fact sheets encompassed in the first report of the TNA project in Jordan the focus was primarily on RWH from residential rooftops for potable and other household uses.

4.2.2. Identification of barriers for roof-top rainwater harvesting

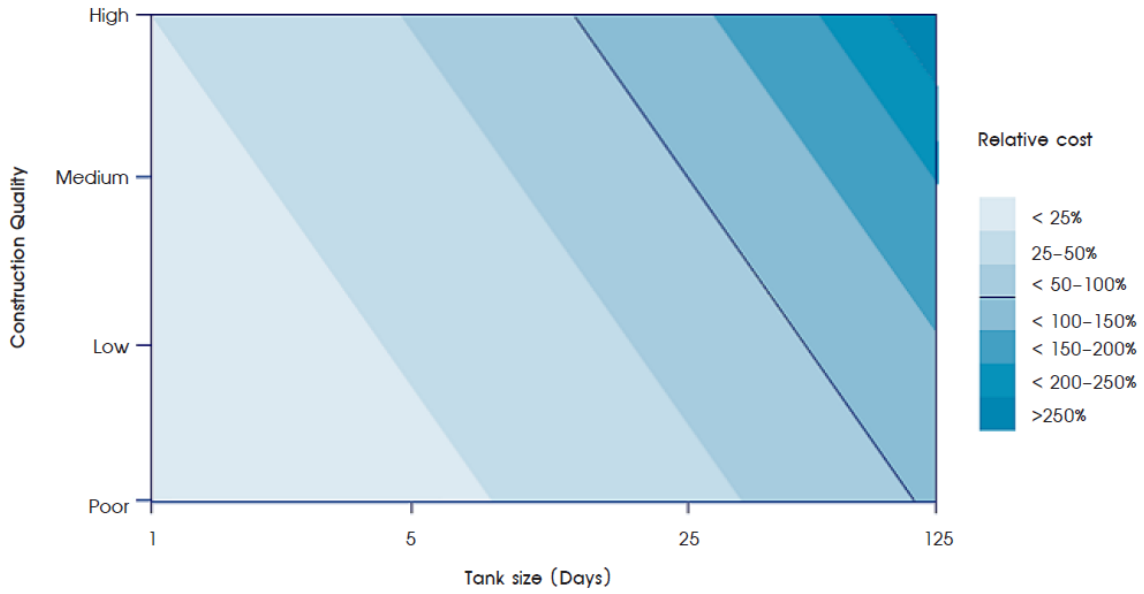
4.2.2.1. Economic and financial barriers

Generally speaking, it was found out during the stakeholder discussions in the main workshop for the BA&EF activity that economic and financial aspects of rooftop rainwater harvesting are not the major obstacles in the road of diffusion of such technology in terms of amount of capital needed. However, it is the feasibility (payback period) that makes this technology unfavourable economically to many households. Internationally, capital investment cost is believed to be affordable for medium- to high-income households while it depends on specifications as well as economic situation (income levels of the country) for low-income households. 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 7 below. Extensive discussion of tank design, construction, and cost can be found in Thomas and Martinson (2007)[22]. 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. The storage capacity of the container needs to meet the demand for water during extended dry periods. In all cases, operation and maintenance still affordable and consists primarily of simple cleaning and basic repairs.

In Jordan, however, the systematic assessment of the economic and financial barriers of rooftop rainwater harvesting conducted for the TNA Project revealed that for a small upper-middle income county like Jordan, the cost of installing and maintaining such practice is still looked at somehow as an economic barrier. This financial burden is primarily due to the cost of preparations works (roof levelling and in many cases the need for putting tile on the roof, dismantling and relocating of already mounted objects on the roof such as water tanks and pipes, satellite dishes, solar water heaters structures, etc) needed before installing the technology itself. A consensus was reached during the BA & EF stakeholders' consultation workshop held on May 10-11, 2016 for Water Sector's market and non-market stakeholders (Figure 8) that the investment in such technology, monetary speaking, is not feasible looking at a relatively long payback period especially in light of quite cheap utility water prices in Jordan.



Source: Thomas and Martinson (2007).[v]

Figure 5: The relationship between cost, construction quality, and tank storage capacity for roof-top rainwater harvesting technology.

The cost benefit analyses exercise (Annex 5) conducted for such technology included capital and maintenance costs as well as the value of other environmental and social benefits. The capital cost of rainwater harvesting systems is found to be highly dependent on the type of catchment, conveyance, cistern

or tank size and storage tank materials used[23]. In addition to the cost of components, there is the cost of having the system installed. The most expensive part of a rainwater system is usually the cistern itself. Rainwater harvesting systems designed as an integrated component of a new construction project are generally more effective than retrofitting a system to an existing building[24].

In Jordan, the cost of a 30 m^3 cistern is around US $1500 to $2800, depending on the material used. The cost of the equipment needed for a basic household rainwater system starts at around $500. Plumbing and fitting costs can exceed $1500, depending on factors such as soil type (excavation cost) and size of the system (pipes, screen, cost of concrete, steel, bricks, plastering, etc)[25]. These costs were estimated by Abdulla and Al-Shareef (2009)[26] based on the 2009 market prices for the different components. The first author (Dr. Abdulla) attended the BA&EF Workshop (Figure 8) and highlighted that current market prices are not expected to have changed considerably from 2009 prices. Thus, such cost figures were used in our CBA works (Annex 5), which revealed, as highlighted above, that investment in such technology is not feasible in Jordan, monetary speaking, looking at a very long payback period especially in light of relatively cheap utility water prices in Jordan. While the total 10-year cost of installing a 30 m^3 cistern was almost USD 5,150, the whole benefit did not exceed USD 1,200 even with assuming an economic incentive of a property tax cut for instance, which is still hard to convince the government's financial department (Ministry of Finance) to adopt, for those who install such system. Again, this is primarily due to under-valued water prices in Jordan, which does not exceed 0.5 JOD per cubic meter paid to the utility or around 4 JOD per cubic meter if purchased from tankers. Thus, the estimations revealed a minus NPV of -3,858.52, -3,828.17, -3,738.03, -3,649.84 for discounts rates of 3%, 4%, 7% and 10% respectively. Sensitivity analyses revealed that even with a hypothetical doubling of water prices in Jordan (and thus increasing the benefits of water saved collected from RWH), the NPV is still minus.

While discussing the cost of roof-top rainwater harvesting, an important consideration that should be taken into account is the quality of rainwater. Sometimes it can be considered the highest water quality when compared to other residential water resources. Costs can be reduced if the system is used as a supplemental water source, and by using local materials in constructing the system. Rainwater harvesting systems can be installed in both new and existing buildings, and the resulting water used for all purposes without treatment except drinking. But before making the decision whether or not to go ahead with a system at home, it is worth considering the water needs against the cost of installing and maintaining it. While the start-up cost of a rooftop catchment system may be significant for low- to middle-class Jordanian household, the long-term operation and maintenance costs are reasonable. In general, maintenance of rainwater harvesting systems is considered to be easy and cheap[27].

Another economic barrier preventing a wide dissemination of such practice in Jordan is the need for a promising program of incentives from the government to encourage households to approach such technology. Household water harvesting is one of the priorities declared by MWI in Jordan in its past and updated water policies and strategies. As indicated above, in a newspaper interview with the Minister of Water in Jordan published in *Al-Rai* local newspaper on Sunday February 28th 2016, His Excellency Minister of Water emphasized the need to resume campaigning for promoting household water harvesting, which according to His Excellency would secure another 7 million cubic meter of water annually[28]. This is almost half

the amount estimated by Abdulla and Al-Shareef (2009) in their study "*Roof rainwater harvesting systems for household water supply in Jordan*"[29]. The two national authors estimated an annual amount of 15.5 million cubic meter of rainwater, which could be collected from roofs of residential buildings provided that all surfaces are used and all rain falling on the surfaces is collected. But regardless of the accuracy of estimation of amount of water that would be collected from rooftop harvesting, which is still considered valuable in a very water-poor country like Jordan it is still a hurdle the high need of introducing a robust governmental incentives program that obstruct the attraction of citizens to such simple technology.

Figure 6: A photo of Water Sector's market and nonmarket stakeholders participated in the BA&EF consultation workshop held on May 10-11, 2016.

Environmental and social benefits considered in cost benefit analyses included: lowering the demand for mains water and releasing that water for other increasing demands; reducing the volume of rainwater discharged (surface run-off) and hence possible contribution to reducing flood risks and the load on sewer systems; cost-saving for chemical, physical and biological treatment before use for most non-potable demands.

Barriers in such broad economic category of a problem were further decomposed into the causes and effects to identify the root cause(s) using the Logical Problem Analysis (LPA) also known as the Problem Tree (Annex 5). The LPA was very useful in bringing together all the key elements of such economic/feasibility problem and thus guide systematic and logical analysis of inter-linked key elements.

4.2.2.2. Non-financial barriers

In the same manner as above, barriers in the broad non-economic categories of problems were further decomposed into the causes and effects to identify the root cause(s) using the LPA tool (Annex 5). Household water harvesting is one of the priorities declared by MWI in Jordan as highlighted above. However, the following barriers were identified as obstacles preventing wide spreading of this practice.

Information and Awareness Barriers

- There is still clear inadequate awareness of the importance of such simple water-saving technology. The low level of familiarity with such practice is evident in both installation, operation, and maintenance;
- No household-targeted marketing campaigns are planned and effectively executed neither from government nor from private sector and water sector-involved organizations.

Human Skills Barriers

- Clear shortage of skillful engineers and contractors in such technology.

Market Condition Barriers

- Inadequate specialized or auxiliary markets oriented toward supplying households or commercial and industrial facilities with units, supplies, and accessories needed to install effective and efficient RWH systems;
- There is still clear absence of efforts from relevant bodies (MWI, Jordan Engineers Association, Contractor Associations, etc) in creating such underdeveloped markets.

Legal and Regulatory Barriers

- Low abidance of dwellings' builders with RWH directive. This is mainly due to both low awareness of the importance of such simple water-saving technology as well as unclear regulations and weak law enforcement concerning household water harvesting directives. New homes and apartment complexes in Jordan were initially (when this directive was first formulated) required to show evidence of having water collection storage tanks as an occupation permit was not supposed to be issued to a newly built dwelling by the in-charge regulatory authorities (such as Greater Amman Municipality in case of Amman City) if such rain water harvesting system was not included in the structure. However, non-compliance with this water conservation requirement was evident and enforcement of such directive was weak. Therefore, the directive was downgraded to only impose dwellings' builders to having just the storage tank but not the whole system, i.e., the system not necessarily to have a roof-top collection system connected to the storage tank. Updated housing regulations did not accept financial penalties in place of securing a water "well" or reservoir in citizens' residences. The decision was made in line with the MWI's policy of maximizing citizen use of water resources and encouraging rainwater harvesting during the winter season. But still the overwhelming majority of houses builders do not abide with such downgraded directive.

Apparently, dwellings' builders trick the regulator by showing just an evidence of any underground storage structure or just even a cap of a structure to get the sought occupation permit. It is worthy to note that RWH practice was followed much more in the past especially in rural areas than now a days. This could be traced to different reasons one of them is the need for extra lands to build more dwellers for accelerating population numbers. In Jordan, there is now no well-defined governmental program to promote rainwater harvesting. However, there are some people that are starting to "voluntarily" collect rainwater in their homes in order to save potable water.

4.2.3. Identified measures

4.2.3.1. Economic and financial measures

- Adequate program of incentives: governmental/NGOs' or other institutes' incentives or direct monetary support/soft loans to lower the capital cost of installing RWH to go in line with declaring household water harvesting as one of the water conservation priorities by MWI in Jordan in its past and updated water policies and strategies. If a household already has a suitable hard roof for use as a catchment surface, storage containers are the major expense. The storage capacity of the container needs to meet the demand for water during extended dry periods. In all cases, operation and maintenance still affordable and consists primarily of simple cleaning and basic repairs. A program of incentives is likely to happen taking into consideration that this has been applied in Jordan in other similar-condition sectors such as energy sector. To that end, a higher number of economic and feasibility studies and financial models should be conducted as well as more value-oriented awareness of the importance of such simple water-saving and adaptation technology should be promoted**.**
- Other accompanying economic incentives such as a property tax cut could also help increase attraction to such practise regardless of the amount of water that would be collected from rooftop harvesting, which is still considered valuable in a very water poor country like Jordan. Property tax option is possible in Jordan since this instrument has been tried in other similar-conditions sectors and the government is willing to support environmentally-friendly practices and technologies based on latest environmental regulations such as the newly revised environmental protection law and the under development water laws.
- Incentives targeting investors in housing sector aiming at providing cuts on sales taxes and other taxes associated with profits from houses construction business (which is relatively high in Jordan);
- Soft loans: introducing low-interest bank loans to support purchasing RWH units, mainly the reservoir;
- Governmental and governorates-development funds should direct some of their allocations towards RWH support programs;
- Reasonable payback period: so that feasibility becomes more favourable economically to many households. To that end, cost of installing and maintaining such practice should be lowered through promoting reasonable system prices through providing soft loans to purchasing storage containers, which are the major expense depending on construction material and quality. Costs can be reduced if the system is used as a supplemental water source, and by using local materials in constructing the system. This will lower the financial burden due to the cost of preparations works.

Thus, reasonable-size, good quality storage container becomes no longer a major investment for poor households. Again this is possible as part of a holistic program of incentives taking into consideration that this has been applied in Jordan in other similar-conditions sectors such as energy sector. Moreover, some NGOs in Jordan are now applying to become Green Climate Fund's accredited agencies; thus, such agencies could be big candidate to design such program of incentives in the water sector. There are some attempts now in this regard in partnership between such NGOs (for example EDAMA and Jordan River Foundation).

- Fair and carefully estimated water utility prices should be considered to alleviate the impact of cheap water prices in Jordan. However, the TNA Project can in this regard support the current calls by the government to re-think water prices and present more realistic prices that take the conditions of the poor into consideration.

4.2.3.2. Non-financial measures

Legal and Regulatory Measures

- Increasing abidance of dwellings' builders with RWH directive. This could be done through revising and updating regulations and directives concerning household water harvesting to meet new developments in the need for such adaptation measures in light of latest assessment conducted in this regard specially those conducted under climate change agenda. Builders of new houses and apartment complexes in Jordan should be clear and aware of legal requirements to have roof water collection systems connected to storage reservoirs to increase their compliance with such governmentally-imposed water conservation requirement;
- Assessing the possibility of not granting construction and operation permits (occupational permits) for buildings not containing RWH layouts in the blueprints of such facilities. Moreover, permits to provide water connection to main lines' service could be tied to showing evidence of RWH compliance.
- Well-defined governmental programs to promote compliance with rainwater harvesting directives are needed embarking collaboration with water and environmental NGOs and CBOs.

Information and Awareness Measures

- Embarking on awareness and information dissemination programs of the importance of such simple water-saving technology encompassing all aspects of environmental and climate change adaption potential, social, and other advantages of the technology, methods of installation, operation, and maintenance. Dedicated programs by the government or involved organizations should be launched to increase awareness of particularly the environmental and social benefits associated with RWH practise, such as but not limited to lowering the demand for mains water and releasing that water for other increasing demands and competing purposes; reducing the volume of rainwater discharged (surface run-off) and hence possible contribution to reducing flood risks and the load on sewer systems; and cost-saving for chemical, physical and biological treatment before use for most non-potable demands;
- Well-defined governmental programs to promote compliance with rainwater harvesting directives are needed embarking collaboration with water and environmental NGOs and CBOs.

Human Skills Measures

- Governmental bodies in charge of water conservation as well as other relevant organizations should develop capacity building programs targeting developing skillful workforces of engineers and contractors particularly specialized in such technology. To that end, more focus should be given to academic programs mainly at civil engineering and architecture departments at national universities and community colleges as well as vocational training programs to build the capacity of such graduates in aspects related to RWH structures and techniques;
- Thus one vital measure in this regard would be introducing dedicated educational programs at universities and vocational training institutions to produce engineers and technicians capable to design, install and maintain such systems.

Market Condition Measures

- Developing and augmenting specialized and auxiliary markets oriented toward supplying households or commercial and industrial facilities with units, supplies, and accessories needed to install effective and efficient RWH systems;
- Dedicated efforts and programs need to be developed from relevant bodies (MWI, Engineers Association, Contractor Associations, etc) to boost creating and augmenting such markets.

4.3. Barrier Analysis and Possible Enabling Measures for Desalination/Brackish Water Treatment and Re-use

4.3.1. General description of desalination/brackish water treatment and re-use technology

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[30]. Purification of brackish and saline water holds the promise of nearly unlimited water resources for human civilizations in in-land and coastal regions. Research and development will continue to make desalination less energy intensive, more financially competitive, and more environmentally benign.

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 and membrane processes. 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[31]. 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[32]. Multiple-effect Evaporation (MEE) (also known as multiple-effect distillation) is another thermal process that utilizes low-pressure chambers.

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[33]. However, the energy efficiency and economics of RO have improved markedly with development of more durable polymer membranes, improvement of pre-treatment steps, and implementation of energy recovery devices. In many cases, RO is now more economical than thermal methods for treating seawater[34].

4.3.2. Identification of barriers for desalination/brackish water treatment and re-use

4.3.2.1. Economic and financial barriers

Assessments and literature review conducted by the consultant supported by outcomes of discussions of the stakeholders participated in the BA&EF Workshop revealed that the technology remains very expensive, making it currently impracticable for most applications. This is in line with point of views from the past ten-year literature, for example, Mohsen (2007)[35] who reported that the cost of a major desalination plant with a capacity of one quarter of a billion m^3 per year is about $1 billion ($600–700 million for basic overhead and about $250 million for required operating expenses for fifteen years). From the technology's product on the other side, a survey submitted by the Commission of the European Communities at the multilateral talks on water shows typical product costs between US$ 1 to US$ 1.7/m^3, depending on process techniques and scale of application[36]. Some global companies active in the business have been offering plants on the drawing board which are supposed to desalinate seawater at product water costs of US$ 0.65–0.70/ m^3 [37]. However, product costs of the plant do not include expenses for water storage and transport from plant to consumer. Thus, even if these relatively low figures are accepted as realistic, total water cost for the consumer would probably amount to at least around US$ 1/m^3.

These costs must be put in relation to the product output per m^3 of water used in agriculture, which is the greatest consumer in the Middle East. According to some studies[38], the volume of water consumed per US$ of agricultural output in some neighboring countries to Jordan is about 0.75 m^3. Conversely, this means that the average value output per m^3 of used water is about US$ 1.3. Consequently, should desalinated seawater be used for irrigation, the value of the yields would just about cover the cost of the water. All remaining labor, investment, and operation costs, including the cost of irrigation facilities, would have to be subsidized. Such studies states that "the maximum water cost that can be borne by agriculture is about US$ 0.25/m^3 which is the maximum product value for water for most irrigated crops grown under normal modern agricultural techniques".

In Jordan, moreover, large-scale seawater desalination has no practicable path, since the only shoreline of the country is at Aqaba and on the Dead Sea, far away from the population and production centers. 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. Judging from these facts, seawater desalination is currently a practicable option only in very exceptional cases, e.g. for domestic or industrial consumption in areas with no other freshwater sources available, or for economic activities like tourism with inelastic water demand in relation to price. Studies and projects were carried out to evaluate the feasibility of water desalination in Jordan[39]. Some of the proposed actions focused on utilizing the water in the Gulf of Aqaba for water supply and desalination for major industries. Technologies used and proposed were multistage flash (MSF) or reverse osmosis (RO) and electrodialysis (ED).

More convenient and thus more realistic in the short term is desalination of brackish water. This is water with an amount of total dissolved solids (TDS) between 1,000 and 5,000 mg/L. To date, the desalination of either seawater or brackish water in Jordan has been very limited. Cost of purchasing a desalination unit such as in farms or a factory still relatively high. Furthermore, any desalination project will be very carefully examined with regards to capital and operating costs. Despite the potential cost reductions involved in the use of large desalination plants, however, 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, however, agricultural uses of desalinated water is growing with time.

Some other economic barrier facing flourishing of such technology in Jordan is that there is absence of directives to provide incentives to locally-produced desalination units, specially spare parts. Thus, some measures should be put to encourage to establish a flourishing market of local products.

4.3.2.2. Non-financial barriers

Legal and Regulatory Barrier

- Absence of directives to regulate installation of licensed desalination units to control inappropriate and illegal disposal of reject water;
- Absence of directives to provide incentives to locally-produced desalination units.

Technical Barriers

- The major technical drawback of current desalination processes is the environmental impacts. The environmental impacts include disposal of the concentrated waste stream and the effects of intakes and outfalls on local ecosystems. The main problem is the disposal of the brine, which can cause tangible environmental problems.
- There is still clear shortage in skillful taskforce to deal with the reject and dispose it based on best industry practices. For example, there is still a need to explore potential of using new techniques, such as solar power, to evaporate reject and dispose salts the right way;
- 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. In addition to the desalting process for this source of water, it has to be transported 350 km to

Amman and even further to other areas. It will also have to be pumped from zero to about 1000 m of static head. The brackish water in Ghore is less costly than that from Aqaba, but it needs to be transported 45 km and pumped from –400 to 1000 (1400) m of static head. Difficulties to exploit the brackish water sources distributed all over the country estimated at hundreds of millions m^3 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 are examples of technical barriers that face such technology.

- The large energy demands of current desalination processes will contribute to greenhouse gas emissions and could set back climate-change mitigation efforts.

Information and Awareness Barriers

- Limited awareness efforts on the importance of such technology and its potential in Jordan.

Human Skills Barriers

- Jordan's experience in brackish water desalination has been fairly limited;
- Limited enough skillful workforce and educational programs as well as vocational training centers in such field.

Market Conditions Barriers

- No support to locally manufactured units since its manufacturing in Jordan is still expensive compared to importing it from abroad.

4.3.3. Identified measures

Results of stakeholder consultations aided with outcomes from solution-tree exercise conducted during BA&EF Workshop (Annex 5) as well as the consultant's own knowledge of the Jordanian overall and water sector's situation coupled with international experiences and investigation of experiences of other countries, the following package of measures could be presented to assist dissemination and wide deployment of desalination/brackish water treatment and re-use in Jordan:

4.3.3.1. Economic and financial measures

- Promoting reasonable system prices for capital and operating costs through cost-effective desalination units integrated with energy solution (such as solar energy) to overcome long distance transportation of pumped desalted water;
- Reducing the cost through technologies that requires less feed water pre-treatment;
- Desalination of brackish water may be accomplished through the use of relatively inexpensive solar energy ponds to get red to reject and reduce environmental treatment cost;
- Cost may be reduced by training enough skillful workforce and developing educational programs as well as vocational training centers in such fields;

- Developing new directives to provide incentives to locally-produced desalination units, specially spare parts. Moreover, spare parts of desalinations units should get the same customs duty waiver granted to main units.
- Securing more international fund support. The construction of an internationally-supported conveyor taking seawater from the Gulf of Aqaba to the Dead Sea to restore the Dead Sea to its natural level will provide the opportunity for very large scale seawater desalination. Such a plant could have a capacity to produce 850 MCM of potable water. ED & EDR may have useful small scale applications;
- Encouraging the salt-tolerant crops to take advantage of water available from desalination plants especially if the output is of high salinity. The goal here is to promoting small-size brackish water desalination projects more favorably than country-scale seawater mega projects or utility-scale groundwater (brackish water) desalination units. The country-scale projects are more of the government concern and there are some on-going attempts to start such activities in Jordan and the government is in the tendering process for a mega desalination project for sea water in the Golf of Agaba. The technology we are targeting is desalination of brackish water by small farmers integrated with planting salt-tolerant crops. This technology is very possible to expand if financial barriers, which are more obstructing than other relatively less important obstacles such as the technical ones (environmental, etc). If we target small farmers who grow crops over brackish water resources but can not afford the financial burden of such technology then we can achieve our target of the TNA as related to this technology. We have conducted further investigation in light of UDP enquiry over the possibility of starting this technology in Jordan and we have figured out that many small farmers are still not familiar with this technology. Thus, if we propose a program of financial support such as soft loans, etc, integrated with advancing solutions to accompanying environmental problems, such as the dilemma of reject water, which could be overcome by planting slat-tolerant crops, then this technology becomes favorable. We have also consulted with Jordan's National Center for Agricultural Research and Extension Center (NCARE) to figure out what crops could be grown on reject water and we have been informed that NCARE had conducted some research over the different crops possible to intake this water and the results were promising. For example Triticale (X Triticosecale Wittmack), the product of wheat and rye hybridization, could be planted on high-salinity water[40]. Triticale has demonstrated high yield potential even under marginal growing conditions and could be a very attractive alternative for raising cereal production globally. Despite the high productivity of triticale, global production is increasing slowly, and the crop has not yet become well established in local or world markets41. The main reason for the lower-than-expected production is that triticale, a good source of protein and energy[42], is used mainly for animal feed but very little for human consumption. Triticale could become a major crop if, in addition to its use as a feed grain, it were cultivated on a large commercial scale for human consumption. According to NCARE, Triticale could be grown on high-salinity water up to 5000 mg/l TDS[43].

4.3.3.2. Non-financial measures

Legal and Regulatory Measures

- Directives should encourage desalination at coastal areas since reject could be disposed to the water bodies with comparison to highlands and Jordan Valley areas where reject is harder to deal with. For inland

applications where amount of desalinated water needed range about 100 m^3/hour and TDS about 3000-4000 ppm, drying beds could be used to get rid of reject using sun heat;

- Directives should provide incentives to locally-produced desalination units and granting customs tax waiver to spare parts but not only main units.

Technical Measures

- Promoting technologies of less environmental impact, which produce less concentrated waste stream and minimize the effects of intakes and outfalls on local ecosystems. The main measure should target reducing impact of disposal of the brine and exploring potential of using new techniques, such as solar power, to evaporate reject and dispose salts the right way and advancing integrated solution such as, in the case of application in agriculture, promoting planting salt-tolerant crops such as Triticale (X *Triticosecale* Wittmack);
- Technologies should require less feed water pre-treatment;
- For the different scattered brackish water sources distributed all over the country and estimated at hundreds of millions m^3 which are still difficult to exploit due to the topography of the country and the distance between these scattered resources, such sources can supply desalted water for small communities by using solar energy or/and wind power so that such measures will reduce impacts of greenhouse gas emissions;
- Exposure to regional and international experience in this regard and exploring best industry practices in the field of desalination, for example the use of evaporators specially those that do not imply additional cost;

Human Skills Measures

- Training enough skillful workforce and developing educational programs as well as vocational training centers in such fields with emphasis on skills and know-how to deal with the reject.

4.4. Barrier Analysis and Possible Enabling Measures for Empowerment and Expansion of WUAs

4.4.1. General description of Water User Association (WUAs)

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. 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[44]. 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; and resolve conflicts related to water use, to name some. 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 (MWI)/Jordan Valley Authority (JVA) in Jordan. The WUA is then able to establish a governing document or constitution, a membership and a bank account.

In Jordan, JVA, along with GIZ, started forming WUAs in the JV about 13 years ago[45]. To date they have formed around 25, with a 19 registered as cooperatives and five in the process of registration. Although legally registered as independent cooperatives, the JVA clearly sees these associations as an operational arm of JVA, with control by JVA. These WUAs cover about 65% of the irrigated area in the Jordan Valley (JV), with the expectation that in the long-run all of the irrigated area in the JV will be served by WUAs[46].

The incumbent law regulating the WUAs in the country is Jordan Cooperatives Corporation's (JCC) Law. WUAs should be govern by Jordan Valley Law and not JCC Law due to the reasons that will follow. JVA's interpretation of the law is that WUAs cannot collect water fees and, even though they are legally for-profit organization, JVA discourages WUAs from carrying out any income generating activities. Therefore, WUAs are dependent upon JVA for funding. At present 12 WUAs have signed Task Transfer (TT) Agreements that provide a limited amount of income, primarily for operational staff salaries. Another four WUAs have signed TT Agreements with no cost to JVA, as all operational activities are carried out by volunteers. Such financial barriers and other technical barrier facing WUAs are elaborated below.

4.4.2. Identification of barriers for empowerment and expansion of WUAs

The identification of barriers for e*mpowerment and expansion of WUAs* was based on investigating and assessing both economic/financial barriers and non-financial barriers. Both categories of barriers are elaborated below. Barrier analysis and enabling framework outlining for such practice was done using Problem Trees and Solution Trees (Annex 5). The most important economic/financial and technical barriers WUAs face were identified based on opinion of directly involved stakeholders representing the governmental body (JVA) that is in charge of the affairs of WUAs at Jordan Valley; as well as consultant's diagnoses of results and outcomes of other assessments conducted by donors active in WUAs-support activities. Examples of such active donors in this field are United States Agency for International Development (USAID) and German Technical Cooperation (GIZ). A main work used in this regard was the assessment conducted by USAID's Jordan Institutional Support and Strengthening Program (ISSP)[47]. The assessment was based on a detailed survey of all existing WUAs as well as a wide range of other stakeholders. It included the 24 WUA chairpersons; WUA member farmers; non-member farmers; JVA personnel; GIZ personnel; Jordan Cooperatives Corporation (JCC) personnel; Ministry of Agriculture personnel; and, other relevant organizations. In total, 79 interviews, 29 consultation meetings, and 7 mini-workshops were held as a part of the said survey. The USAID assessment covered different aspects such as technical and financial information on the operation and performance of WUAs in managing retail water distribution as well as the costs incurred by JVA. The economic, social, and environmental impacts of WUAs involvement were also assessed in the said study. Based on consultant's own assessment and utilizing literature resources such as the literature cited above, the main financial and technical barriers facing WUAs identified are:

4.4.2.1. Economic and financial barriers

- Weak financial sustainability of WUAs in Jordan. This is mainly due to:
  - inability to recover water costs;
  - limited finance for instance to rehabilitate the irrigation network;
  - weakness in developing income-generating projects; and
  - weakness of WUAs' marketing skills and competitive abilities of framers' products.
- Financial deficiency in the contracts with JVA. Current TTAs cover staff salaries, but include only limited amounts to cover other fixed and variable WUAs' costs. A new and simpler contracting mechanism is needed based on lump sum payments by WUAs to JVA for the quantities of bulk water delivered to them;
- Cost of improving system condition. Much of the JV irrigation network is more than 30 years old and in poor condition, with a substantial backlog of deferred maintenance. Rehabilitation of the network is a top priority across the JV, but particularly in the Southern Ghors, where WUAs refuse to take over any maintenance responsibilities due to the poor condition of the infrastructure and anticipated high cost and efforts[48].

4.4.2.2. Non-financial barriers

Legal, Regulatory, and Institutional/Organizational Barriers

- Problem with incumbent law. The binding law regulating the WUAs is Jordan Cooperatives Corporation (JCC) Law. Which means the current legal framework for the WUAs is provided by the Jordan Cooperative Law No. 18, 1997 (Cooperative Law) and Regulation 13, 1998 (Cooperative Bylaw) and overseen by JCC. This situation is complicated by the present arrangements of WUAs registered as for-profit cooperatives under the JCC umbrella who are allowed for collecting fees for irrigation water services. This form of registration is an expedient, resorted to in the absence of a more appropriate legal mechanism for legally registering WUAs[49]. This is not a good legal arrangement for WUAs, who according to entities active in the water sector in Jordan such as JVA (who was established according to the Jordan Valley Development Law No. 18 of 1977 and amended Jordan Valley Development Law No 30 for the year 2001 to reflect the transformation in JVA role and functions) should not be in charge of collecting fees for irrigation water services and both JVA and the WUAs recognize this. This form of registration of WUAs is the result of the fact that there are no articles in the amended Jordan Valley Development Law under which a WUA could be registered, nor is there a separate law designed for WUA establishment[50]. In retrospect both the WUAs and JVA are unhappy with this arrangement and are now actively exploring other legal options. However, at the time that WUAs were first being established, it was determined that while not perfect, this was the most suitable existing legal framework to allow WUAs to be created to increase farmer participation in irrigation issues. As cooperatives in Jordan are for-profit organizations while WUAs are non-profit, JCC initially refused to register them, but after pressure from both farmers and JVA and some special arrangements, they finally agreed. JCC has stated that WUAs "lack the cooperative culture" and also they lack knowledge of what is required from JCC[51]. The process of registering them as cooperatives was forced. JCC recognizes that they are not profitable and need some profitable projects to ensure their sustainability, such as profit margins on the price of water. Given their lack of cooperative orientation, JCC would not be opposed to them being registered as a different type of legal organization[52]. Ultimately, the prevailing understanding of the situation, mainly from JVA side, is that WUAs should be govern by Jordan

Valley Law and not JCC Law, since this legal situation in turn is causing the following institutional/organizational barriers:

(i) Minimizing JVA control on the amount of activities assumed by WUAs in order to keep the control under JVA. JVA wants to remove WUAs from the umbrella of JCC and bring them under its own control. In this regard JVA has drafted a series of amendments to the JVA Law to accomplish this. However WUAs do not necessarily see this as being in their best interest. A serious additional problem is that in the future WUAs will be signing contracts for bulk water supply with JVA and there will be a serious conflict of interest here under the arrangement proposed by JVA. The proposed amendments tend to serve the interests of JVA but WUAs are not convinced that being under the direct supervision of JVA is best for them. They feel they need their own legal framework, one that clearly recognizes their rights and responsibilities as well as those of the bulk water supplier. This is in line with the legal bases of WUAs all over the world which usually involve registration under a standalone legislation, for instance, a WUA Law that clearly specifies the roles and responsibilities of the WUA leaders, members and hired employees. The key issue is that WUAs have a role that is halfway between the public and the private sector. They undertake a public service function yet are controlled in a democratic manner by their members. It is understood that the process of passing a WUA Law in Jordan is slow and cumbersome. An alternative suggested is to register WUAs in Jordan as non-profit companies under the Companies Law No. 22 of 1997. This appears to be a valid possibility although a lawyer needs to exam the law carefully to see the strengths and weaknesses of such a course[53];

(ii) Threatening JVA Staff's job security since JVA's staff fear losing their jobs in the long term if such jobs are to be performed by WUAs in the future. This is knowing that WUAs recognize that JVA needs them yet at the same time wants to control them and thus limit the tasks they are allowed to assume. Moreover, the overall belief is that both farmers and WUAs prefer to have the retail water services delivered by WUAs, provided that they are well equipped.

(iii) Imposing financial constraints to WUAs. As pointed out above, JVA's elucidation of the law is that WUAs cannot collect water fees (must be non-profit) thus JVA discourages WUAs from carrying out any income-generating activities even though they are legally for-profit organization according to JCC Law. Therefore, WUAs are dependent upon JVA for funding. Without the right to collect water fees and given the resistance to WUAs developing their own funding sources, there has thus far been little need for financial management skills at WUAs. Yet clearly WUAs have to have income and the ability to manage in order to cover their management, operation and maintenance (MOM) costs as they grow and mature. At present WUAs are receiving almost all their MOM funding from TTAs[54].

- Institutional obstacles for expansion of responsibilities and transfer of additional tasks. The current position of WUAs under JCC's mandate still causes institutional obstacles to transfer full service responsibilities such as maintenance mandate for main irrigation networks and pumps. The current legal basis for organizing WUAs is ill-suited to the structure and operations of WUAs and will not accommodate an expanded role in irrigation retail distribution. WUAs have shown that under incumbent regulatory set-up even with limited training and working in worn irrigation facilities, that they are somehow capable of managing retail water delivery in a competent and professional manner. However, a new legal framework must be put in place providing a suitable basis for a democratic non-profit organization that can contract with JVA for

bulk water services. The legal framework should empower WUAs institutionally to set its own rates and collect service fees from all clients in its service area. Some WUAs appear already ready to take on additional responsibilities above the tertiary distribution system. Others will achieve this capability as their skills develop through training and experience[55]. Additional responsibilities could include pump station operation and monitoring responsibilities along the King Abdullah Canal. Selective transfer of these kinds of responsibilities should be pursued to take advantage of the developing capabilities of some WUAs and to gain experience with the process to facilitate replication.

Technical Barriers

- Technical obstacles in current operations and challenges to transfer maintenance and rehabilitation mandate for main irrigation networks and pumps. One major challenge is improving system condition. Much of the JV irrigation network is more than 30 years old and in poor condition, with a substantial backlog of deferred maintenance. Rehabilitation of the network is a top priority across the JV, but particularly in the Southern Ghors, where WUAs refuse to take over any maintenance responsibilities due to the poor condition of the infrastructure. Other maintenance skills needed to be improved is to enhance responses to pipeline breaks and leaks using advanced techniques.

- Other important technical needs that surfaced include some need for work-related vehicles, equipment, mainly maintenance equipment, and tools to measure and monitor water flow and pressure. Key training needs include computer skills and operational and maintenance skills for water distribution.

Human Skills Barriers

- The high need for continuous training and capacity building programs specifically for financial management and sustainability skills, grant writing skills, governance and overall management skills, operation and maintenance of water distribution systems and computer skills to enhance the overall managerial capabilities of WUA staff. Many countries have limited experience with WUA and, as a result, farmers as well as Government irrigation officials have little understanding of participatory irrigation management. Consequently, government, donors, WUAs and WUA members have recognized that WUA capacity development requires an extensive training program[56]. Given the lengthy involvement of some donors, for example GIZ, it is rather surprising to see the relatively small amount of training that has been provided for WUAs in Jordan[57]. In addition, these activities have been focused primarily on management activities, with little training in governance, although this is an important element in a participatory association such as a WUA. In order for WUAs to expand their responsibilities they require a training program that has a mix of training for hired employees, WUA leadership and WUA members. Training for WUA members is especially important as the main decisions in WUAs such as electing the Council members and establishing the annual WUA fees are made by the General or Representative Assembly which is made up of the members.

- Low ability in archiving work documents and other documentation activities of information and transactions in a way that make information ready and useful to share;

Market Condition Barriers

- Weakness in marketing the concept of WUA as an innovation in Participatory Irrigation Management as well as clear weakness in marketing WUAs' products and demonstrating its added value.

Networking Barriers

- Weak coordination and communication platforms between WUAs themselves and between each WAU's members;

Social, Cultural, and Behavioural Barriers

- Strong effect of tribal system and personal connections;
- **Job security. JVA staff members are concerned about their long-term employment** security **as WUAs take over more and more of their present tasks.**

4.4.3. Identified measures

4.4.3.1. Economic and financial measures

- The most viable economic and financial measure that WUAa need to enjoy is attaining effective means of financial sustainability of such highly needed organizations. Any financial sustainability system deployed should entail ability to recover water costs and rehabilitate the irrigation network. WUAs have to have income and the ability to manage effectively in order to cover their management, operation and maintenance (MOM) costs as they grow and mature. Based on some previous studies an assessments mainly performed by donors concerning the sustainable costs for MOM to a WUA, it is believed that the sustainable costs for MOM of their systems is around 6-7 JD/du or $85-$99/ha[58]. As presented by some experts, for example Eng. Saad Abu Hammour, JVA Secretary General [59] at the 2010 Arab Water Week, water costs to WUAs, including MOM costs and payments to the bulk water supplier, are expected to be in the range of 12 to 14 JD/du or ($169-197/ha) in the near future[60]. Thus, WUAs will have to cover all of their own MOM costs as well as paying for irrigation water provided to them by the JVA. For growers producing high value cash crops, especially for export, payments of around $200/ha for water supplies are just part of their production costs and are covered by their revenue from crop sales. However, for small growers and those producing for the domestic market, care will be needed to insure that the fees charged to them are affordable. To that end, a new and simpler TTAs contracting mechanism is needed based on lump sum payments by WUAs to JVA for the quantities of bulk water delivered to them;
- Most importantly, an essential economic measure is to empower WUAs to build their capacity to develop income-generating activities and projects with emphasis on building their capabilities and competencies on marketing and increasing products' competitiveness. This require empowering WUAs's overall financial and administrative systems;
- Grant programs should be available to enable WUAs' member farmers to own equipment and vehicles necessary for their daily works such as loaders, etc., to compliment daily functions;

4.4.3.2. Non-financial measures

Legal, Regulatory, and Institutional/Organizational Measures

- Switching from the mandate of incumbent law, Jordan Cooperative Corporation (JCC) law, which is currently regulating the WUAs, to the sovereignty of Jordan Valley Law. This will (i) backstopping such democratic non-profit organizations and supporting accommodating an expanded role in irrigation retail distribution to empower the mandate of WUAs to contract with JVA for bulk water services; (ii) empowering WUAs to set its own rates and collect service fees from all clients in its service area and removing the financial constraints to WUAs related to collecting water fees and carrying out income generating activities so that WUAs are not dependent upon JVA for funding; (iii) removing conflict of interests between JVA and WUAs and eliminate competition over control on the amount of activities assumed by WUAs. So that this will establish their own legal framework, one that clearly recognizes their rights and responsibilities as well as those of the bulk water supplier and most importantly eliminate threatening JVA Staff's job security since JVA's staff fear losing their jobs in the long term if such jobs are to be performed by WUAs in the future; (iv) enabling some farmers organizations to union together to form a bigger body such as organizations councils. The later proposed institutional/organizational instrument is important since WUAs need a mechanism for joining together to facilitate interaction among WUAs and to represent WUA interests in dealing with JVA and other outside parties. A proposed (for example by GIZ and JVA joint activities in WUA's projects) framework for such larger governance body[61] is forming a Council of WUA representatives. This transformational change will entail setting the regulation governing WUAs in a way that empowers WUAs to become the central entities for all other farmers-related activities and endeavors. A revised legislative framework for WUA establishment and operation should make provision for a formal associative body of all JV WUAs.
- Propose amendments to the JVA law and by-law to enable an empowerment to WUAs and attaining their administrative and financial independency; establishing a legal basis of the relationship between the WUA and the bulk water supplier vacant of any conflict of interest status; promote for attaining economies of scale for operation and maintenance of the main irrigation infrastructure; and state the legal basis for WUAs to form national associations of WUAs to promote and protect the rights of the irrigation sector;
- Or support other options currently under discussion62 such as that of registering WUAs as non-profit companies under the Companies Law No. 22 of 1997 as amended. This appears to be a reasonable possibility, but it requires a thorough legal vetting before moving forward. An important positive aspect of registering WUAs under the Companies Law is that it is not forced under the umbrella of JVA since the later status involved a clear conflict of interest, since WUAs will be contracting directly with JVA for water services. This option and other options will be assessed further in the TAP and pilot project formulation phase phase based on consultation with other involved donors in the sector.
- Overall, any new legal arrangements should aim at removing institutional obstacles for expansion of responsibilities and transferring of additional tasks to WUAs and transferring full service responsibilities such as maintenance mandate for main irrigation networks and pumps. The new legal framework must be put in place providing a suitable basis for a democratic non-profit organization that can contract with JVA for bulk water services. The legal framework should empower WUAs to set its own rates and collect service fees from all clients in its service area.

Technical Measures

- Technical capacity building programs to prepare farmers for a major mandate of transferring maintenance and rehabilitation to their authority for main irrigation networks and pumps;

- Building technical capacity of WUAs members in the overall capacity of improving the 30 years old system condition particularly in the Southern Ghors due to the poor condition of the infrastructure. Other maintenance skills needed to be improved is to enhance responses to pipeline breaks and leaks using advanced techniques;

- Other important technical needs include build capacity to operate some work-related vehicles, equipment, mainly maintenance equipment, and tools to measure and monitor water flow and pressure. Key technical training needs include computer skills and operational and maintenance skills for water distribution;

- Training programs on skills of archiving work documents and other documentation activities of information and transactions in a way that make information ready and useful to share;

Market Condition Measures

- Capacity building programs to empower WUAs in marketing the concept of WUA as an innovation in Participatory Irrigation Management;

- Building the capacity and skills of WUAs in marketing their products and demonstrating its added value.

Network Measures

- Developing and activating effective coordination and communication platforms between WUAs themselves and between each WAU's members;

Human Skills Measures

- Establish a program of continuous training and capacity building specifically for financial sustainability skills, grant writing skills, management and governance, operation and maintenance of water distribution systems and computer skills to enhance the overall managerial capabilities of WUA staff and to increase both the capability of WUA staff and the ability of WUA member farmers to participate in democratic governance of their WUA. Such tailored capacity building programs should be designed in a holistic approach and in collaboration with sector-active donors such as USAID and GIZ and to establish sustainable WUAs that are technically and financially viable. A suggested WUA capacity development program typically includes the following courses:
    - WUA formation and registration
    - WUA governance, leadership, and democratic principles such as providing training to WUA members on their duties as members of the General Assembly
    - Irrigation service fee establishment
    - WUA financial management and accounting (general financial skills required for a socially, financially and technically viable WUA)

- Archiving work documents and other documentation activities of information and transactions in a way that make information ready and useful to share;
- Irrigation water allocation and system operation
- Responsibilities of representatives
- Irrigation system management
- Maintenance planning and implementation
- Pump operation and maintenance

- Support the establishment of a dedicated and expanded WUA support unit within JVA to support WUA capacity building and human skills development;

Social, Cultural, and Behavioural Measures

- Promote awareness campaign of good governance to minimize effect of personal factors such as tribal system and personal connections;

4.5. Linkages of the barriers identified

There is clear linkage with regard to the common economic/financial barriers controlling the dissemination of the water sector's technologies of roof-top harvesting and the desalination. Both are not financially viable and require capital investment. Thus, the linkage at the measure level could be presented as a governmental incentive of tax cut or other financial instruments (such as soft loans) for both technologies to encourage household resident and farmers to purchase and install roof-top harvesting and desalination respectively. While both technologies (household rainwater harvesting and desalination) require awareness campaigns to increase the level of the public knowledge of the importance of such water conservation practices, it is clear that the two technologies above as well as the Water User Association practice all share a common barrier of a big need for skillful human resources. The three technologies require human skills-related measures and programs of capacity building responsive to competencies that need systematic strengthening. There is still clear shortage on skillful engineers and contractors in the case of roof-top harvesting technology, while in the case of desalination there is high need for training enough skillful workforce and developing educational programs as well as vocational training centers in such fields with emphasis on skills and know-how to deal with the reject. In the case of WUAs, the high need for continuous training and capacity building programs specifically for financial sustainability skills and developing training programs on grant writing skills are evident.

Thus, it is believed that since members of WUAs (the farmers) are either already operating or will sooner or later operate desalination units at their farms to purify brackish water from their groundwater wells, a joint capacity building program on the needs of the two practices is recommended to maximize synergies, and optimize the use of resources and effects of recommended measures.

Another barrier-related linkage is in the legal and regulatory domain. Both rainwater harvesting and desalination suffer from absence of directives to provide incentives to locally-produced desalination units and to households that deploy rainwater harvesting structures. Thus, since the two technologies are regulated under the mandate of MWI/WAJ's governance system, the two technologies could be addressed concurrently in any future revision of the relevant laws, by-laws, regulations, etc, aiming at providing an enabling

environment for the two technologies in the context of addressing climate change adaptation at the national level.

4.6. Enabling framework for overcoming the barriers in Water Sector

Based on the common economic/financial barriers for the two market technologies of the water sector that were assessed for interlinkages, namely, roof-top harvesting and the desalination, it is strongly believed that an effective component of an enabling framework for both technologies is a governmental incentive of tax cut or any viable financial instrument (such as soft loans) for both technologies to encourage household resident and farmers to purchase and install roof-top harvesting and desalination units. Another component of the enabling framework for both technologies is developing robust awareness campaigns to increase the level of the public knowledge of the importance of such water conservation practices. As articulated above in the barrier linkages section, it is clear that the two technologies of roof-top water harvesting as well as the Water User Associations practice all share common barrier of a big need for skillful human resources. Thus, an important element of an effective enabling framework for the three technologies should address human skills-related barriers. There is still clear shortage on skillful engineers and contractors in the case of roof-top harvesting technology while in the case of desalination there is high need for training enough skillful workforce and developing educational programs as well as vocational training centers in such fields with emphasis on skills and know-how to deal with the reject. In the case of WUAs, the enabling framework should focus on the high need for continuous training and capacity building programs specifically for financial sustainability skills and developing training programs on grant writing skills particularly. All relevant entities from governmental side (mainly MWI, JVA), as well as sector-active donors side (such as USAID and GIZ) should collaborate together to develop such capacity building programs. Finance of such activities could be sought from relevant funds such as Adaptation Fund Program at Ministry of Planning and International Cooperation (MoPIC). This should be part of the broader context of widespread water sector reform and capacity building, an going activity supported by major development donors in Jordan such as USAID, where one of the core principles of such reform program is the separation of bulk water supply and retail service delivery[63]. The final policy objective is to determine the best options, as well as the best approach and timing, to achieve full irrigation water management coverage by WUAs across the entire Jordan Valley. A good example of a cost-effective program of measures as part of a larger national-level development of enabling framework is illustrated in the case of WUAs members and desalination at farms. Since members of WUAs (the farmers) are either already operating or will sooner or later operate desalination units at their farms to purify brackish water from their groundwater wells, a joint capacity-building program on the needs of the two practices directed to members of WUAs is recommended to maximize synergies, and optimize the use of resources and effects of recommended measures.

At the legal and regulatory sphere, an element of the enabling framework targeting both rainwater harvesting and desalination would be directed to the barrier of absence of directives to provide incentives or any financial instrument (such as soft loans) to locally-produced desalination units and to households that deploy rainwater harvesting structures. Thus, since the two technologies are regulated under the mandate of MWI/WAJ's supervisory system, the two technologies could be addressed concurrently in any future revision of the relevant laws, by-laws, regulations, etc, aiming at providing an enabling environment for the two

technologies in the contexts of addressing climate change adaptation at the national level. In this regard, this recommendation of the BA&EF report will take advantage of such climate technologies-related outcomes to re-emphasize again the need for developing a water sector's standalone adaptation strategy and action plan. This targeted and highly needed climate change adaptation strategy for the water sector will serve as an implementation tool of the provisions of the national *Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020* as related to the water sector. In such recommended water sector adaptation strategy, the adaptation technologies highlighted and elaborated in the TNA Project as national priorities would be a central component of the strategy to present a holistic and integrated approach for Jordan to adapt to the impact of climate change in the water sector.

5. AGRICULTURE SECTOR

5.1. Preliminary Targets for Technology Transfer and Diffusion for Agriculture

Agricultural production is closely tied to climate, making agriculture one of the most climate-sensitive of all economic sectors[64]. As illustrated in the TNC (2014)[65], 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. TNC analyses demonstrated that most of agricultural areas in Jordan are rain-fed which makes agriculture in Jordan more susceptible to climate change. As elaborated in Jordan's INDCs[66], 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. The key adaptation targets as related to the TNA objectives are in line with the measures set in the INDCs of Jordan to respond to climate change in the agricultural/food security sector, which will be setting and implementing a sustainable agriculture policy addressing;

- Developing 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;
- Supporting environment friendly agriculture and permaculture designs as well as conservation and sustainable utilization of plant and animals genetic resources for food and agriculture that are climate resilient and adaptive to climate change especially landraces to improve rural sector adaptive capacity to changing environment to enhance food security;
- Maintenance of old Roman wells for water harvesting purposes and establishment of new wells in the rural area;
- Use of different crops varieties and modification of cropping pattern and crop calendar including planting and harvesting dates;
- Implementation of supplemental irrigation, water harvesting techniques, maximizing treated waste water re-use in agriculture, improving water use efficiency and the augmentation of drip irrigation in irrigated areas and utilization of saline water in the irrigation of crops tolerant to salinity;
- For rain-fed areas: adaptation measures include, but not limited to, improving soil water storage to maximize plant water availability by maximizing infiltration of rainfall; application of conservation agriculture, which involves minimum soil disturbance and encompasses land preparation techniques that improve soil fertility; managing crop residue and tillage and conserving soil and water; using of supplemental irrigation from harvested rainwater in the critical stages of crop growth 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 to be constructed to provide supplementary irrigation water to a number of small farms or fields by using the micro-dams;
- Selection of tolerant crop varieties: shifting to cultivating crops that are more tolerant to droughts or lower water requirements;
- Raising awareness and declarations on Climate Intelligent Agriculture, etc;

The three prioritized technologies for the agriculture sector as identified by stakeholders (Figure 7) were: i) *Support of Water Saving Technologies, such as Drip or Subsurface Irrigation*; ii) Farm *Water Harvesting*; and iii) *Introduction of Plant Varieties Resistant to Climate Change*. These technologies were classification as follows: i) consumer goods, ii) capital goods, and iii) non-market goods, as shown in Table. 9.

Table 5: Technology classification according to type of goods for agriculture sector

Consumer Goods	Capital Goods	Other non-market Goods
- Water saving technologies, such as drip or subsurface irrigation Technology. -Water Harvesting	- Promotion of plant varieties adaptive to Climate change	

Figure 7: A photo of Agriculture Sector's market and nonmarket stakeholders participated in the BA&EF consultation workshop held on May 10-11, 2016.

5.2. Barrier Analysis and Possible Enabling Measures for Application of Water Saving Technologies, such as Drip or Subsurface Irrigation Technology

To identify barriers of this technology as well as the other two top technologies of the agriculture sector, the following process was followed:

i) A literature review of policy papers and other pertinent documents (Table 10);

ii) A desk study that included economic and other relevant assessments of the technology;

iii) Workshop including stakeholders from the government and private sector (Figure 7).

iv) Consultations with experts and stakeholders.

iv) Market mapping tool-consumer goods and capital goods (Annex 6).

The following Table (Table 6) lists all references used in the assessment.

Table 6: List of documents reviewed by the Agriculture Sector's consultant:

• Jordan's Third National Communication on Climate Change, 2014 • Assessment of the Agricultural Sector in Jordan , Volume I ,2012 • Strategic plan of the Agriculture Sector in Jordan 2014 • National Strategy for Agricultural Development, 2003 • Water Strategy and Policies 2008 for the period from 2008-2022 • Irrigation Equipment and System Design Policy of 2008 • National Agenda, 2006-2015 • Irrigation Water Allocation and Use Policy of 2008 • National Water Demand Management Policy of 2008 • Jordan's Water Strategy 2008-2022: Water for Life • Jordan Valley Agriculture Strategy Plan 2003-2008 • National Strategy and Action Plan to Combat desertification 2006 • ***Websites*** • FAO Country Profiles; www.fao.org/countries • World Bank databank; data.worldbank • Central Bank of Jordan: www.cbj.gov.jo • Department of Statistics: www.dos.gov.jo

5.2.1. General description of the Application of Water Saving Technologies, such as Drip or Subsurface Irrigation Technology

In principle drip irrigation is a very efficient way to apply water. Actual results depend on system design, operational practices, water quality and other factors. Although some irrigation equipment manufacturers, on their own, follow standards to a level that enables the exports of some of their products, drip application

and filtration equipment used in Jordan varies greatly in quality, longevity, and price. This affects both farm profitability and water use efficiency. In addition poor system design also contributes to poor results and inefficient water use. Design skills for drip irrigation systems are limited, and many farmers rely on second-hand advice from other non-professionals in laying out their systems. A targeted course in drip irrigation system design, leading to certification, would help fill this knowledge gap by creating a core crop of qualified professional system designers. These skills could then be disseminated to others, building on a firm base.

Efficient use of irrigation water will be very important due to expected water scarcity forecasted in light of climate change for Jordan. Drip irrigation can help use water efficiently. A well-designed drip irrigation system reduces water run-off through deep percolation or evaporation to almost zero. If water consumption is reduced, production costs are lowered. Additionally, conditions may become less favorable for the onset of diseases including fungus. Irrigation scheduling can be managed precisely to meet crop demands, holding the promise of increased yield and quality.

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.

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. Agricultural chemicals can be applied more efficiently and precisely with drip irrigation. Fertilizer costs and nitrate losses can be reduced. Nutrient applications can be better timed to meet the needs of plants. Application of this technology successfully lines with the country's economic, social and environmental development priorities. Moreover, it contributes to food security priority, by increasing productivity and land fertility, as well as leading to increase of income of rural population and reducing out-migration.

5.2.2. Identification of barriers for Water Saving Technologies, such as Drip or Subsurface Irrigation Technology

A review of relevant literature and available resources and reports, meetings with manufacturers and sellers of irrigation equipment and researchers , and NGOs was used to identify a list of all possible barriers impeding the transfer and diffusion of water saving irrigation systems under local conditions. Those barriers were then prioritized through stakeholder's consultation workshop. Application of water saving technology

barriers related to technology implementation has been assessed within several aspects such as economic/financial barriers, technology barriers, capacity building barriers and social barriers.

5.2.2.1. Economic and financial barriers

The main economic and financial barriers hindering the uptake of water saving technologies among small farmer communities were identified as:

- High initial investment required for purchase of various units of the equipment (main pipes, lateral, sub-lateral pressurised PVC pipes, water tanks, fittings, tanks, pump), transport and installation cost;
- Limited economic incentives for the purchase of irrigation equipment and to use water efficiently;
- High capital investment needed for creating irrigation water sources /investment in water storage and supply infrastructures;
- Limited economic incentive for saving water due to inefficient pricing of water;
- High interest rate on loans;
- Cost involved in renewing irrigation system (drip) which has a life time of around 7 years;
- High cost involved in design, installation and maintenance (high labour requirement).

Water saving technologies require large investments and have high infrastructure costs. The average cost per hectare is around 24,000 USD. Higher costs are generally associated with the costs of pumps, pipes, tubes, emitters and installation. Most of the small farmers (consumers) in the Jordan Valley and Highlands cultivating irrigated lands need to finance at least 75% of the technology cost. Usually they cannot afford such investments and have a weak access to acceptable financial means; therefore, it is necessary to design an enabling framework for access to long-term and low-interest loans for land-owners and farmers. Lending organizations that would provide such financing are the Agricultural Credit Corporation and the Microfinance institutes in the country. The average payback time ranges from 5-10 years depending on the loan amount.

5.2.2.2. Non-financial barriers

Technological barrier: The Lack of technological knowledge and skills related to the design of the network (low efficiency) the operation and maintenance. The quality and quantity of water delivered to farms.

Legal/regulatory: Also, the improper pricing mechanism for use of irrigation water. The current pricing system is based on the water amount supplied irrespective of the type of crops grown. Some crops water productivity is higher than others.

Capacity/information: One important barrier of the implementation of the technology is weak capacity and limited technical knowledge and skills of farmers on application of water saving technologies. Besides to the limited access to information and weak agricultural extension services, another barrier is the low level of awareness of economic and ecological advantages.

Social barriers: Unfamiliarity with new technology could also be mentioned as a social barrier to application of the technology. Local farmers are accustomed to applying traditional irrigation methods during the cultivation process.

5.2.3. Identified measures

5.2.3.1. Economic and financial measures

In order to overcome existing economic and financial barriers to the application of water saving technologies, and based on discussions and consultations with all relevant government representatives, the following measures are proposed:

- Specific tax regulations in order to promote private sector investments for local production of water saving technologies;
- Subsidized tariff on irrigation water saving practices should be provided by the Ministry of Water and Irrigation in order to increase efficient use by land-owners and farmers;
- Develop specific subsidy mechanism by the Ministry of Water and Irrigation for farmers to enhance application of water saving technologies on private lands;
- Provision of long-term and low-interest loans through different state funds, private sources (different banks) and international funds (IFAD) to support farmers in application of the technology. The Agricultural Credit Corporation and the Microfinance institutes in the country are willing to support this.

5.2.3.2. Non-financial measures

In order to overcome existing non-financial barriers to the implementation of water saving technologies, the following measures could be proposed:

- Implement pilot projects by the National Center for Agricultural Research and Extension (NCARE) and national research institutes to practically demonstrate results and achievements of application of water saving technologies;
- Information campaigns on the advantages of applied technology must be organized and funded by NCARE and research institutes in order to increase capacity of farmers (both small-scale and large-scale farmers) by closely involving local authorities and NGOs sector in the process;
- Agricultural extension services must be significantly improved and enhanced in order to provide necessary advisory services and capacity building activities on advantages of the technology.

5.3. Barrier Analysis and Possible Enabling Measures for Water Harvesting

5.3.1. General description of the Farm Water Harvesting technology

Collection and storage of farm 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. Farm rainwater collection can also contribute greatly to the stabilization of declining

groundwater tables. 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; and
- Groundwater aquifers can be recharged by directing water down.

Micro-catchments are often used to “store” water as soil moisture for agriculture. Small reservoirs are typically used in areas with seasonal rainfall to ensure that adequate water is available during the dry season. Many run-off control methods for irrigation incorporate inundation or extended contact time with soils to increase topsoil moisture. Traditional methods were often developed in response to local conditions and have been practiced for centuries. Examples of these practices include variations of contour farming, which is broadly defined as plowing or digging trenches perpendicular to the direction of run-off flow; this slows rainfall, decreasing erosion and increasing infiltration. Many areas in the country receiving low amounts of rainfall (below 300 mm) are potential sites. Rainwater collected from the ground surface is typically used for non-potable purposes, including irrigation, general domestic use, and livestock. However, in some regions with seasonal rainfall small reservoirs are commonly used for drinking water supply during the dry season, despite the high turbidity and poor bacteriological quality of the water.

Application of this technology successfully lines with the country’s economic, social and environmental development priorities. Moreover, it contributes to water priority by improving quality and increasing amount of water, as well as to the strategy of diversification of the country’s economy by improving the water sector within the economic system. Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts.

One of the possible disadvantages of the technology could be that the costs of the new technology and its maintenance can be higher than others. Users may need to be provided with necessary capacity building and awareness raising activities in order to adapt new technology.

5.3.2. Identification of barriers

Barriers related to the technology have been identified in six categories: i) economic/financial barriers, ii) policy/regulatory barriers, iii) capacity/information barriers, iv) technology barriers, v) social barriers and vi) environmental barriers.

5.3.2.1. Economic and financial barriers

- Insufficient governmental support for enhancement research activities in the application of this technology could be mentioned as a financial barrier to technology diffusion.
- High capital costs for large-scale harvesting projects, which include building large reservoirs, public tanks, and channels, may exceed local capacity.
- Weak access to financial sources for people in these regions could be mentioned as another financial barrier.

5.3.2.2. Non-financial barriers

Policy/regulatory barriers include the following:

- Lack of stakeholder network for the development and transfer of the technology;
- Lack of support for research institutions (state and private) to provide deeper analysis for selection of most relevant technology;
- Inadequate institutional basis and lack of coordination;

Capacity/information barriers include:

- Inadequate capacity and lack of skills of existing research institutions;
- Limited technical knowhow by the farmers regarding the use of this technology;
- Farmers' inadequate awareness with new technology;
- High human skills requirement (low capacity to sustainable use of technology)

Technological barriers:

- Difficulties in identification of suitable site and scale of rainwater reservoirs or tanks;
- Variability in terrain and soil conditions which require different site-specific techniques;
- Climatic conditions such as drought.

Social/Environmental barriers:

- Possible conflicts between communities on water access rights;
- Land tenure and ownership problems, which results in land division among owners into small areas. This creates land use conflicts;
- Risk of disease outbreaks among people and cattle due to the use of same water source;
- Possible negative environmental impacts in the downstream of reservoirs and water bodies where sediments can accumulate in those reservoirs.

5.3.3. Identified measures:

5.3.3.1. Economic and financial measures

In order to overcome existing economic and financial barriers to the implementation of efficient water systems technology, the following measures were discussed with all relevant stakeholders including the governmental organizations:

- Increase government fiscal support to R & D institutions;

- Enable provision of long-term and low-interest loans or grants through state funds, private sources (different banks) and international funds (WB, IFAD, GEF, GCF, Adaptation Fund);
- Develop specific subsidy mechanism to promote application of the technology.

5.3.3.2. Non-financial measures

In order to overcome existing non-financial barriers of technology implementation, the following measures were discussed with all relevant organisations:

- Information campaigns to raise public awareness on the advantages of applied technology;
- Support the creation of a stakeholder network for the development and transfer of the technology (through a network of technical experts);
- Support capacity building activities for technology development and transfer through focused training;
- Improve legislative and regulatory reforms to stimulate the application of the technology;
- Develop support policies (specific subsidy mechanism) to encourage local deployment of the technology;
- Implementation of pilot projects to demonstrate the advantages of the technology.

The government and non-government organizations in the country will fund those activities.

5.4. Barrier Analysis and Possible Enabling Measures for Introduction (or Promotion) of Plant Varieties Resistant (Adaptive) to Climate Change Technology

5.4.1. General description of the introduction (or promotion) of plant varieties resistant (adaptive) to climate change

The 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 to enhance plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses. Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a particular farm, taking into account the different returns from value-added crops with complementary marketing opportunities. New and improved crop species can be introduced through farmer experimentation with new varieties. Agricultural researchers and extension agents can help farmers identify new varieties that may be better adapted to changing climatic conditions, and facilitate farmers to compare these new varieties with those they already produce. 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.

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. Application of this technology successfully lines with the country's economic, social and environmental development priorities. Moreover, it contributes to food security priority, by increasing productivity, and to the strategy of diversification of the economy, by increasing weight of agricultural sector within the economic system, as well as leading to increase of income of rural population. The process of farmer experimentation and the subsequent introduction of adapted and accepted varieties can potentially strengthen the farmers cropping systems by increasing yields, improving drought resilience, boosting resistance to pests and diseases as well as by capturing new market opportunities.

One of the possible disadvantages of the technology could be that the costs of new species and their cultivation can be higher than others. Farmers may need to be provided with necessary capacity building and awareness raising activities in order to adapt new technology. Farmers may also face risk from poor economic returns if crops are not selected based on a market assessment.

5.4.2. Identification of barriers

Barriers related to deployment of introducing crop species resistant to expected climate change technology have been identified in five categories: i) economic/financial barriers, ii) policy/regulatory barriers, iii) capacity/information barriers and iv) social barriers.

5.4.2.1. Economic and financial barriers

- Insufficient governmental support for enhancement research activities in selecting and testing more heat tolerant crop species could be mentioned as one of the barriers for technology diffusion. Additionally, there is limitation of financial support for research institutions (state and private) to provide deeper analysis for selection of most heat tolerant and durable crop varieties. Financial support for the organizations of testing those varieties are inadequate;
- Weak access to financial sources for local farmers could be mentioned as a financial barrier. Most farmers do not have access to financial sources with acceptable terms in order to purchase high quality seeds and provide all the necessary agro-technical measures.

5.4.2.2. Non-financial barriers

Policy/regulatory barriers: The government of Jordan has a supportive policy for agricultural development. However, there is no specific supportive mechanism (subsidy or any other stimulations) related to promoting the application of crop species resistant to climate change.

Capacity/information barriers: One important barrier of the implementation of the technology is weak capacity and lack of skills of existing research institutions. Current capacity of research institutions is not up-

to-date and does not meet requirements. Special technical in screening testing and selection of varieties should be provided in order to improve technical capacity of those institutions.

Social barriers: Unfamiliarity with new technology could also be mentioned as a social barrier to application of the technology. Local farmers are accustomed to applying traditional seeds during the cultivation process. They do not have enough information on the benefits of new species. Non-existent or inefficient agricultural extension services could be mentioned as another barrier.

5.4.3. Identified measures

Identifying relevant measures is the process of analyzing necessary actions to be taken in order to overcome current barriers to the implementation of prioritized technologies. These measures should have sustained the diffusion. For the identification of relevant measures, detailed analysis of current practices at national and international level was provided. Measures have been identified based on grouped barriers.

5.4.3.1. Economic and financial measures

In order to overcome existing economic and financial barriers to the introduction (promotion) of new species resistant (adaptive) to forecasted climate change, the following measures could be proposed:

- Government financial support to research institutions should be increased in order to improve their technical capacity;
- Develop specific subsidy mechanism for farmers to enhance application of new crop species;
- Provision of long-term and low-interest loans through different state funds and international funds (World Bank, IFAD) to support farmers in application of new species.

5.4.3.2. Non-Financial measures

In order to overcome existing non-financial barriers to the introduction (promotion) of new species resistant (adaptive) to forecasted climate change, the following measures could be proposed:

- Capacity and skills of research institutions must be improved by involvement in different trainings or international study tours with the support of government or other donor organizations;
- Technical capacity of research institutions must be improved in order to enable them to implement different researches and studies;
- Strengthen international research network program in order to learn from effective best practices applied throughout the world;
- Implement pilot projects to practically demonstrate results and achievements of application of new adaptive crop species to farmers;

- Information campaigns on the advantages of applied technology must be organized and funded in order to increase capacity of farmers (both small-scale and large-scale farmers), by closely involving local authorities and NGOs sector in the process;
- Agricultural extension services must be improved and enhanced in order to provide necessary advisory services and capacity building activities to farmers.

5.5. Linkages of the Barriers Identified

Some of the identified barriers are similar throughout all technologies. For instance, weak capacity and lack of information on use and advantages of the technology are some of the main barriers to deployment of all prioritized technologies under agricultural sector. Unfamiliarity with new technology could also be mentioned as a social barrier to application of prioritized technologies. Local population is accustomed to traditional irrigation and cultivation practices.

With regard to water saving technologies, regulatory actions from the government are needed on the tariff system in order to increase efficiency of irrigation water use. High cost of investment and infrastructure is another barrier to the wide application of the technology. Not having access to low-interest and long-term financial means, private farmers are unable to provide sufficient investment for the development of the technology.

Social barriers are also important, as local farmers are unaware of economic and environmental advantages of the technology. Besides to the resistance to change and Cultural biases

5.6. Enabling Framework for Overcoming the Barriers in the Agriculture Sector

Agriculture is a strategic sector for Jordan and the government has approved specific development programmes in this field. Main aspects of agricultural development are more specifically represented by the "Jordan Agriculture Development Strategy (2016-2020). However, almost all development programmes are lacking in aspects related to future tendencies of climate change. Therefore, specific measures are necessary in order to overcome existing barriers to the implementation of the prioritized technologies.

This section discusses the vital elements of the enabling framework that should be enhanced to improve the quality and efficacy of the technologies for agricultural sector transfer and diffusion. The enabling frameworks are those resources and conditions that are generated by institutions which are beyond the immediate control of the beneficiaries. In brief, the enabling framework provides the environment conducive for the transfer and diffusion of adaptation technologies for the agricultural sector. The enabling environment for the agricultural sector should encompass the following main elements to enable the country to overcome identified economic/financial and non-financial barriers of the prioritized technologies:

- Modify lending procedures to enable provision of long-term and low-interest loans or grants through state/government funds, private sources (different Banks) and international funds (WB, IFAD, GEF, GCF, Adaptation Fund).

- Develop specific subsidy mechanism to promote application of the different technologies. This can be financed by governmental and non-governmental organizations.
- Integrate incentive polices for diffusion of the new technologies.
- Capacity building for research institutions
- Strengthen international research network programs.
- Enhance and improve agricultural extension services.
- Information campaign on the advantages of applied technologies.
- Implement pilot projects at community (municipal) level.

Capacity building activities include activities related to awareness raising and increase of knowledge of all related stakeholders such as decision-makers, technology users, and service providers of applied technology. These include organization of round-table discussions, training sessions, workshops, seminars and study tours for relevant technologies.

Information campaign on the advantages of applied technology is the measure used to address the barrier of “Low level of awareness of economic and ecological advantages”. It is considered an effective tool to raise awareness level of the advantages of the technology. This includes dissemination of information on technology advantages, as well as current opportunities for national and local decision makers and local communities (technology users), through mass media, publications, organization of workshops and seminars.

Subsidy mechanisms are effective tools to promote and stimulate application of the technologies. At present, most of the farmers cannot afford to buy and apply relevant technology. This is a financial barrier and could be eliminated by improving access to reasonable financial resources, such as credits.

6. REFERENCES

1 Jordan Third National Communication Report to UNFCCC (2014)
2 Jordan's TNC to UNFCCC (2014)
3 Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen.
4 Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen.
5 Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen.
6 Jordan INDCs to UNFCCC (2015)
7 Updated Master Strategy of Energy Sector in Jordan for the period (2007-2020) (MEMR 2007)
8 http://investor.firstsolar.com/releasedetail.cfm?ReleaseID=864332
9 http://www.pv-magazine.com/news/details/beitrag/jordan-launches-plan-to-install-solar-on-6-000-mosques_100018618/#axzz4BqEk0AhD
10 Jordan's Third Competitiveness Report- The Transportation Sector, Amman, Jordan, 2010-2011 (MoPIC 2010)
11 The project started to be implemented at the time of preparing this report (personal communication with GAM/Anoud Al-Fawwaz July, 2016).
12 climatetechwiki.org
13 climatetechwiki.org
14 AFD BRT Project, Jordan
15 IPCC, 2007
16 ITDP, 2007
17 IPCC, 2007
18 IPCC, 2007
19 http://www.unep.org/transport/lowcarbon/PDFs/TNA_TransportChapter.pdf
20 Jordan Third National Communication Report to UNFCCC, 2014
21 Pacey & Cullis, 1986
22 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.
23 Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. Desalination (243): 195–207.
24 An introduction to rainwater harvesting—general description. Global Development Research Center, Osaka, Japan, 2002.
25 Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. Desalination (243): 195–207.
26 Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. Desalination (243): 195–207.
27 Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. Desalination (243): 195–207
28 Minister of Water and Irrigation, Press Meeting, Al-Rai newspaper (Sunday February 28th 2016).
29 Abdulla, F.A. and Al-Shareef A.W. (2009). Roof rainwater harvesting systems for household water supply in Jordan. Desalination (243): 195–207.
30 Khawaji, A.D., Kutubkhanah, I.K. and Wie, J.M. (2008) Advances in seawater desalination technologies
Desalination Vol. 221:47–69.
31 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.
32 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.
33 Khawaji, A.D., Kutubkhanah, I.K. and Wie, J.M. (2008) Advances in seawater desalination technologies Desalination Vol. 221:47–69.
34 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46
35 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46
36 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46
37 D. Hoffman, Potential applications for desalination in the area. In: J. Isaac and H. Shuval, eds., Water and Peace in the Middle East. Studies in Environmental Science, No. 58, Elsevier, Amsterdam, 1994.
38 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46
39 Mohsen M. S., (2007). Water strategies and potential of desalination in Jordan, Desalination 203 (2007) 27–46
40 NCARE, personal communication 2016
41 Triticale improvement and production by Mohamed Mergoum and Helena Gómez-Macpherson; Food and Agriculture Organization of the United Nations (FAO) 2004.
42 Hill, 1991
43 NCARE, personal communication 2016
44 Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon (the complete report could be accessed from the TNA project website http://tech-action.org/).
45 "Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
46 Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program
47 "Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
48 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.

49 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
50 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
51 51 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
52 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013
53 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
54 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
55 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
56 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
57 "Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
58 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
59 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
60 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
61 "Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
62 Jordan Valley WUAs: Future Roles And Responsibilities Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
63 "Existing Conditions Survey and Assessment of Water Users Association in the Jordan Valley Report" USAID/Jordan Institutional Support and Strengthening Program (ISSP), May 2013.
64 Jordan INDCs to UNFCCC (2015)
65 Jordan TNC to UNFCCC (2014)
66 Jordan INDCs ro UNFCCC (2015)

Climate Change *Technology Needs Assessment* (TNA) Project

National Workshop no. III (Barrier Analyses and Enabling Framework)
May 10-11, 2016--Jordan Valley Marriott Resort and Spa Hotel

Agenda

DAY ONE: Tuesday May 10th 2016:

9:00	Take off from Amman to Dead Sea
10:00-10:30	Arrive in Dead Sea (Jordan Valley Marriott Resort and Spa Hotel)
10:30-11:00	Check in/Registration for the Workshop (***Coffee Break 1***)
11:00-11:05	Start of workshop program: Welcoming Remarks
11:05-11:30	Lecture no. 1 Introduction, TNA Project Progress to Date, Objectives of Workshop and Technology Categories and Market Characteristics (slides 1- 26)
11:30-12:00	*Exercise no. 1* ***Characterization of adaptation and mitigation technologies to assess barriers (30 min)***
12:00-1:00	*Lecture* no. 2: General methods for identifying and analyzing barriers (slides 27-38)
1:00-2:00	**Lunch**
1:30-3:00/3:30	*Exercise no. 2: Problem trees to identify and categorize barriers (30-45 minutes each technology)*
3:30-3:45	*Lecture* no. 3: *Barrier analysis for market goods: consumer and capital goods/Market Mapping,, Until slide 59 (**Barriers for behavioral change)*** (slides 39-59)
3:45-4:00	***Coffee Break no. 2***
4:00-5:30	*Exercise 3: Market mapping—only to Market-based Consumer Goods (30 min. per technology, total 90 min. max.)*

7:00-8:00 Dinner

Climate Change *Technology Needs Assessment* (TNA) Project

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Agenda

Day TWO Wednesday May 11th 2016:

7:00-8:00	Breakfast and room check out + **Coffee Break**
8:00-9:00	Lecture no. 4: Measures to overcome barriers (slides 60-70)
9:00-11:30	Exercise 4: Solution Trees: Translating Barriers into Measures
11:00-11:30	**Coffee Break and resuming room check out**
11:30-12:00	Lecture no. 5: ***Assessing measures and sets of measures to be included in the Technology Action Plan (TAP)*** (slides 71-82)
12:00-1:30	Exercise ***5: Economic Assessments of transfer and diffusion of a technology***
1:30-1:45	Workshop conclusion and closing remarks
1:45-2:45	**Lunch**
2:45-3:00	Boarding bus to leaving to Amman

Annexes

Annex 2: Roster of stakeholders participated in the BA&EF consultation workshop held in the Dead Sea Area from 10-11 May 2016.

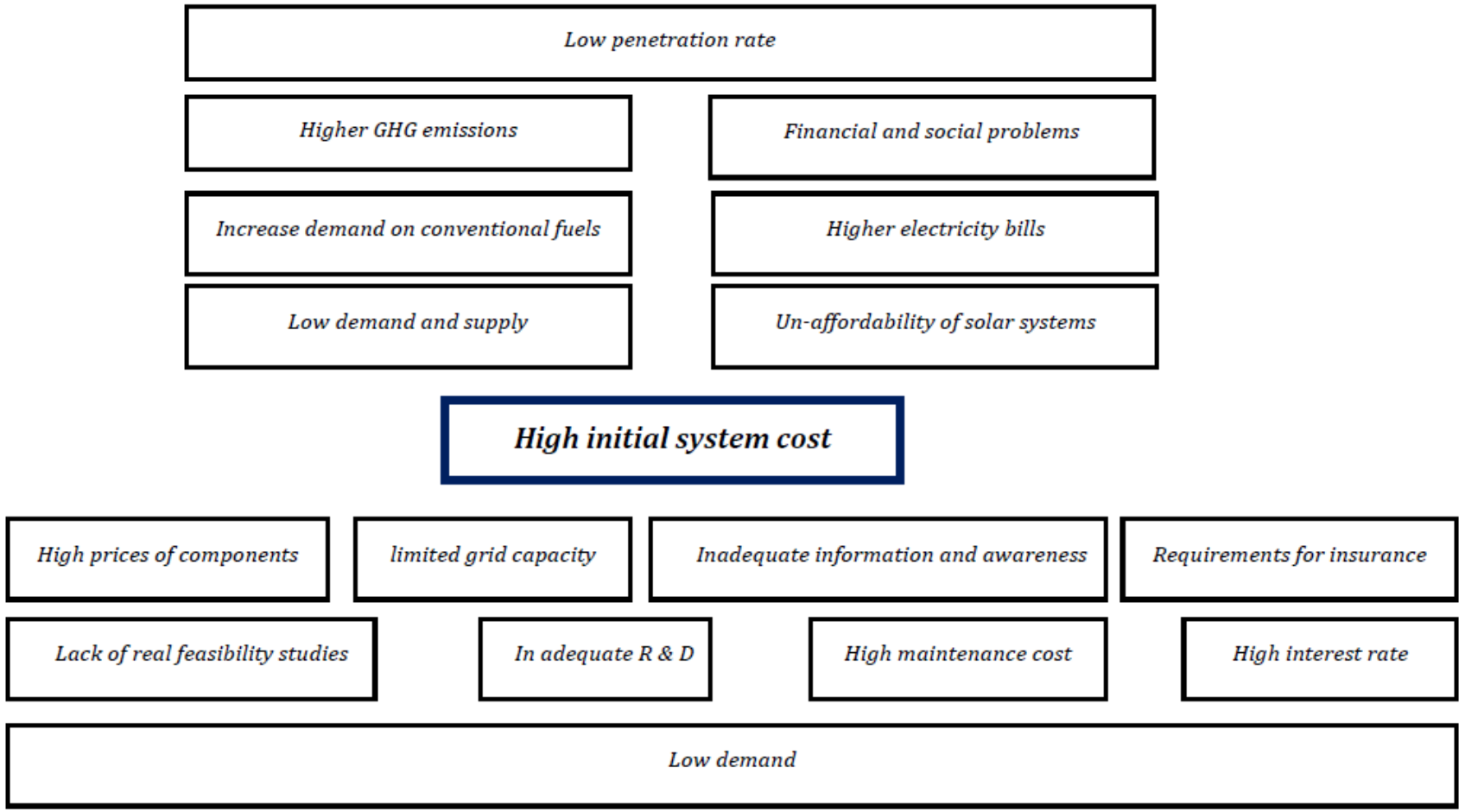
No.	Name	Organization	Sector	Email Address	Phone #
1.	Rateb Aladwan	WAJ	Water	jwtdu@yahoo.com;	0798503409
2.	Anoud Fawwaz	GAM	Transport	Anoud91@gmail.com	0789994192
3.	Yara Shahrouri	Aqua Trat	Water	yks@aqua-treat.com	0799271111
4.	Saeb Khresat	JUST	Agriculture	skhresat@just.edu.jo	0796600222
5.	Hasan Ibrahim Zamat	Privet sector	Water	w.technology@yahoo.com	0795288822
6.	Anwar Adwan	JVA	Water	Adwan_anwar@yahoo.com	0798207143
7.	Ayman El-Hadid	MOA-water harvesting directorate	Agriculture	aalhadid@yahoo.com	0799038533
8.	Ali Ghnaim	Privet sector	Transport	Ali_ghnaim@yahoo.com	0776945656
9.	Mahmoud alkhras		Agriculture	info@faimaijo.com	0777343923

		Fai and mai company			
10.	Mohammed Alqinna	Hashemite University	Agriculture	qinna@hu.edu.jo	0796700222
11.	Nerdeen abu Aboud	MoEnv	Energy	nerdeen@yahoo.com	0777811268
12.	Zaidonel- Nsour	GAM	Transport	Zaidounqasem@yahoo.com	0799054565
13.	Rawda Qandeel	MoEnv	Transport	qandeelr@outlook.com	0796544777
14.	Hanadi Marie	MoEnv	Water	hanadimarie@yahoo.com	0795643935
15.	Eva Hammoudeh	LTRC	Transport	Eva.hammoudeh@ltrc.gov.jo	0786666275
16.	Ahmad Alsuwi	kawar energy	Energy	ahmad.suwi@kawar.com	0796611765
17.	Naim Hassan	MOT	Transport	nhassan@mot.gov.jo; Naeem.Hassan@MOT.GOV.JO	0796848463
18.	Sara Alhaleeq	MoEnv	Water	Sara_alhaleeq@hotmail.com	0779270077
19.	Fayez Abdulla	JUST	Water	fabdulla@just.edu.jo	0795880016
			Agriculture		

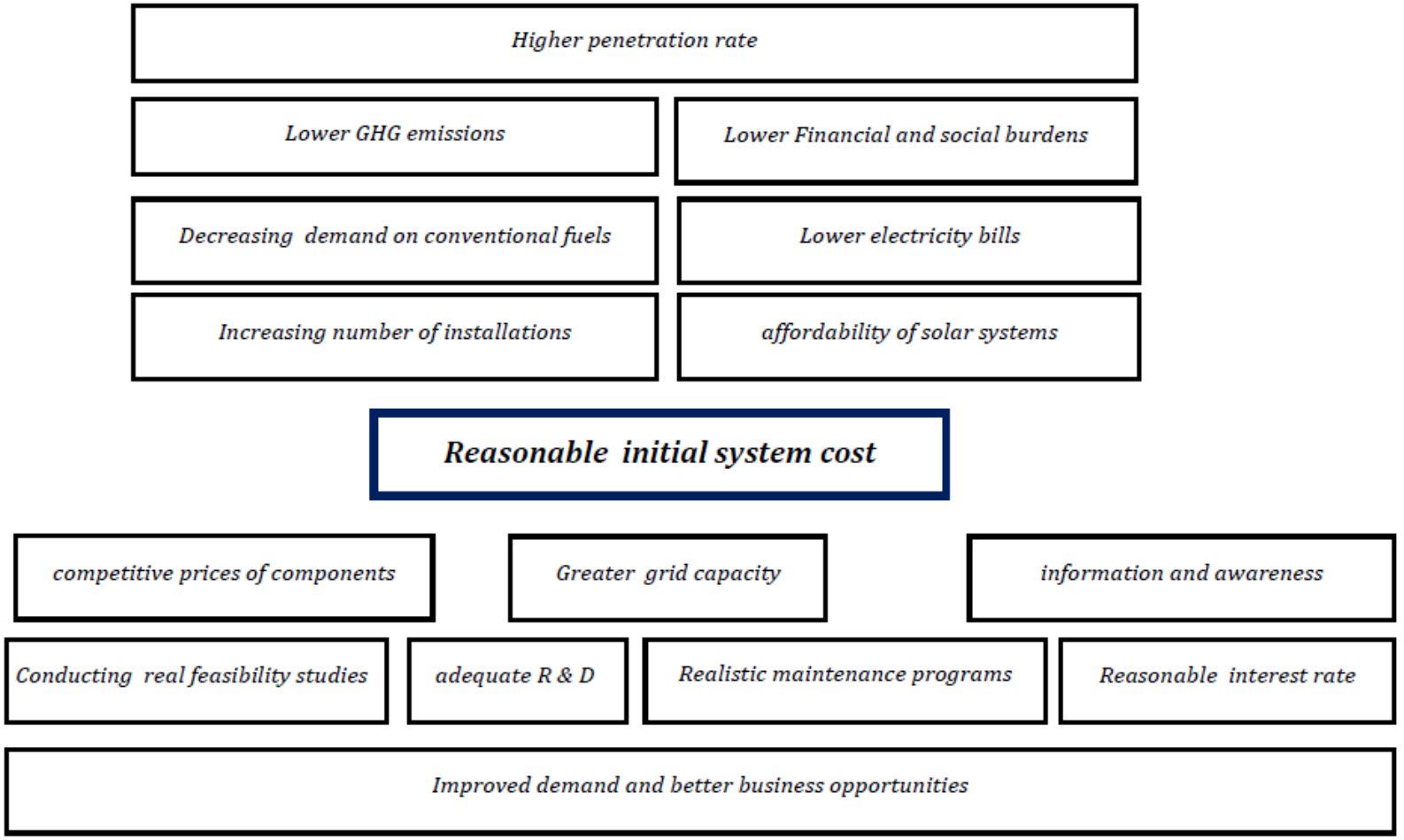
20.	Nasab Alrawashdeh	NCARE		nasab@ncare.gov.jo	0777176439
21.	Hala Arar	MOT	Transport	harar@mot.gov.jo	0795823553
22.	Imad Hanania	Hanania system	Energy	Imad.hanania@yahoo.com	0795615615
23.	Eng. Rasha Qadura	MOT	Transport	Rasha.Qadora@MOT.GOV.JO	
24.	Rana albashtawi	RMU/WAJ	Water	Rana_albashtawi@mwi.cov.jo	
25.	Eng. Wafa Dabis	MoEnv	Energy	wafadabis@hotmail.com	
26.	Ibrahim Odeh	Almakan	Energy	odeh@hotmail.com	
27.	Ahmad Abdelfattah	Almakan	Water	anafiz@yahoo.com	
28.	Ahmad Noubani	Almakan	Transport	ahmad_noubani@hotmail.com	

Annex 3: Energy Sector Market Mapping, Problem Tree, and Solution Tree: Energy Sector--Problem Tree

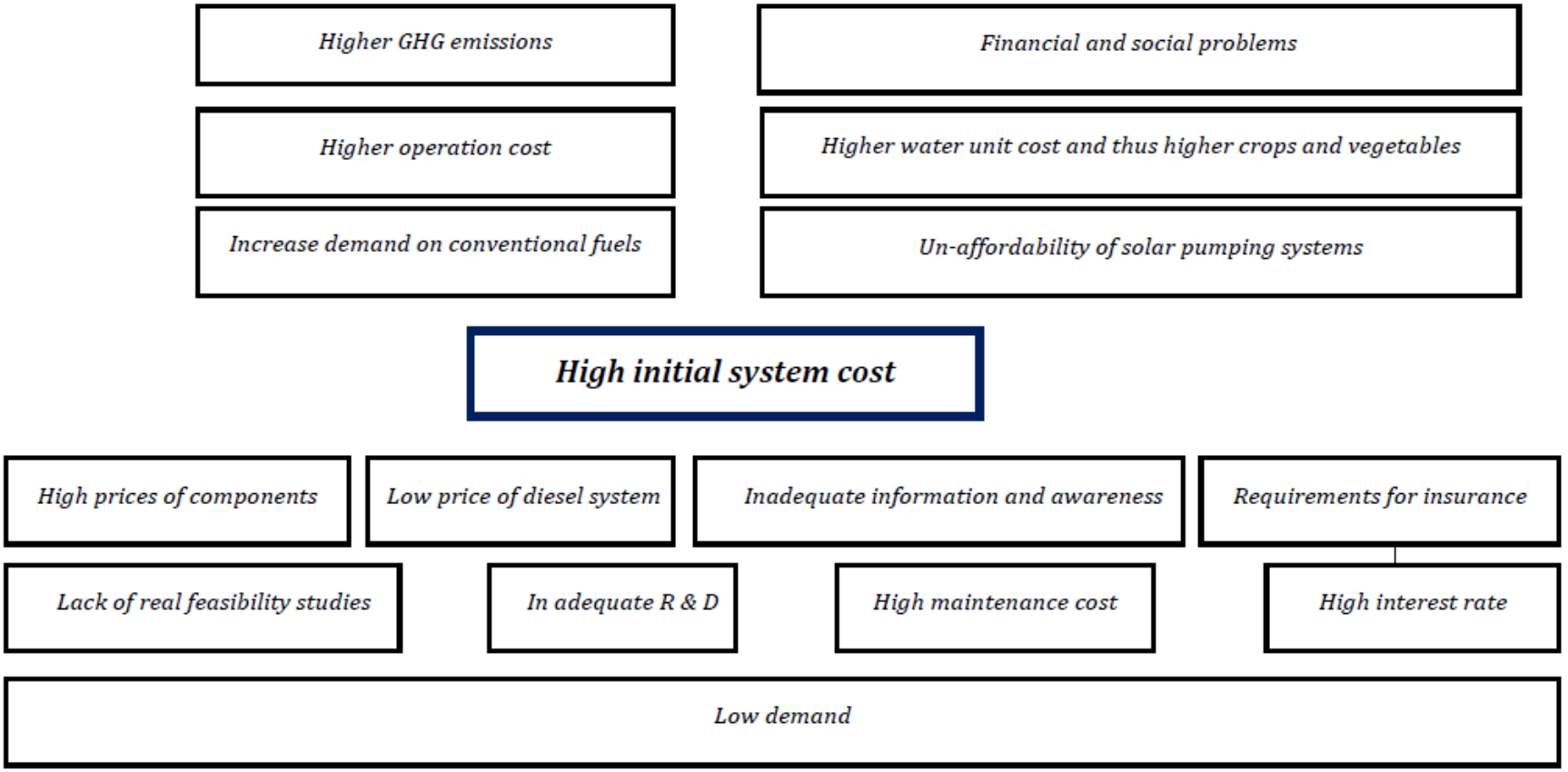
ANNEX 3 A-1: Problem tree for the Solar PV electrification technology



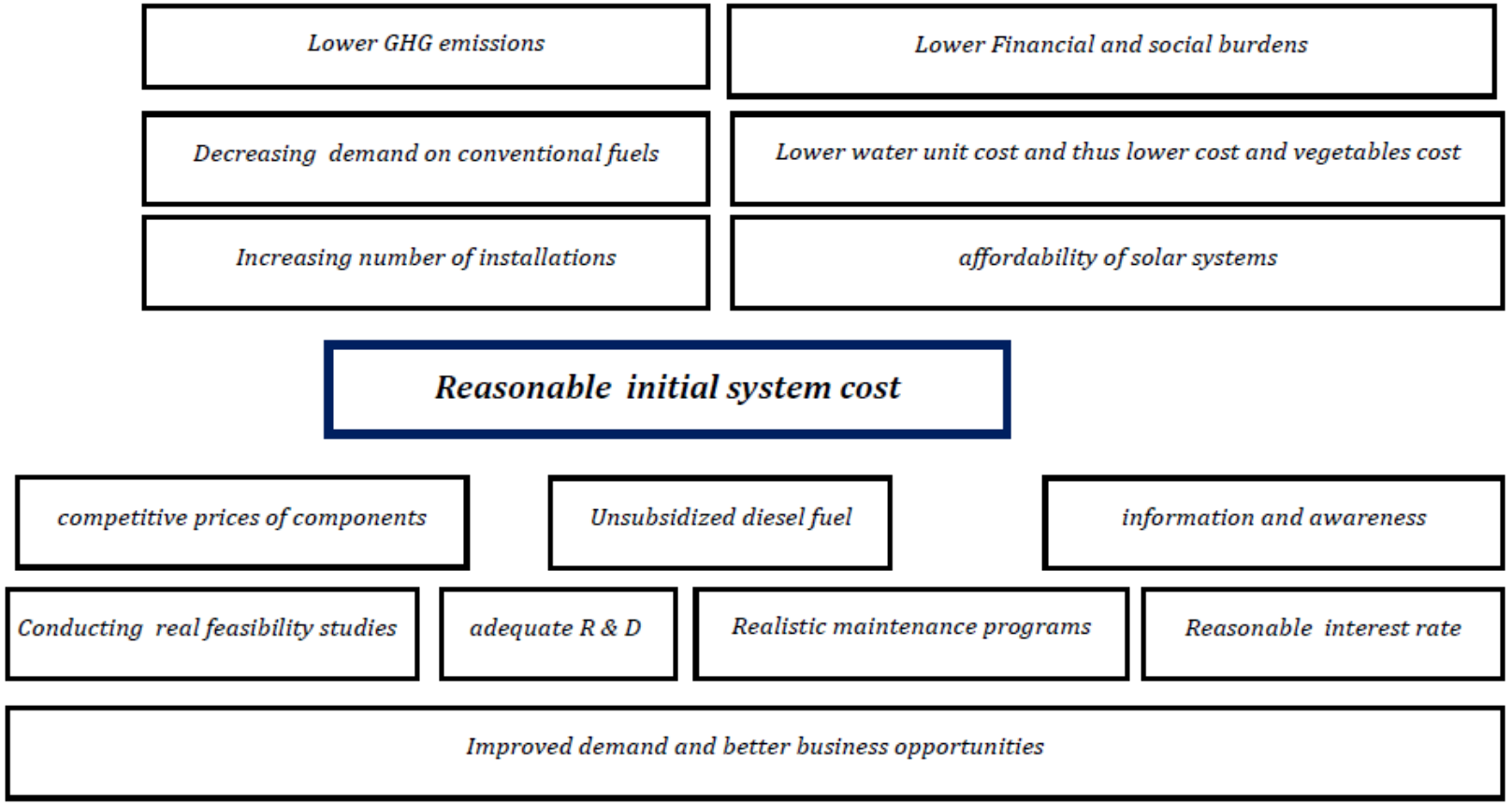
ANNEX 3 B-1: Objective tree for the Solar PV electrification technology



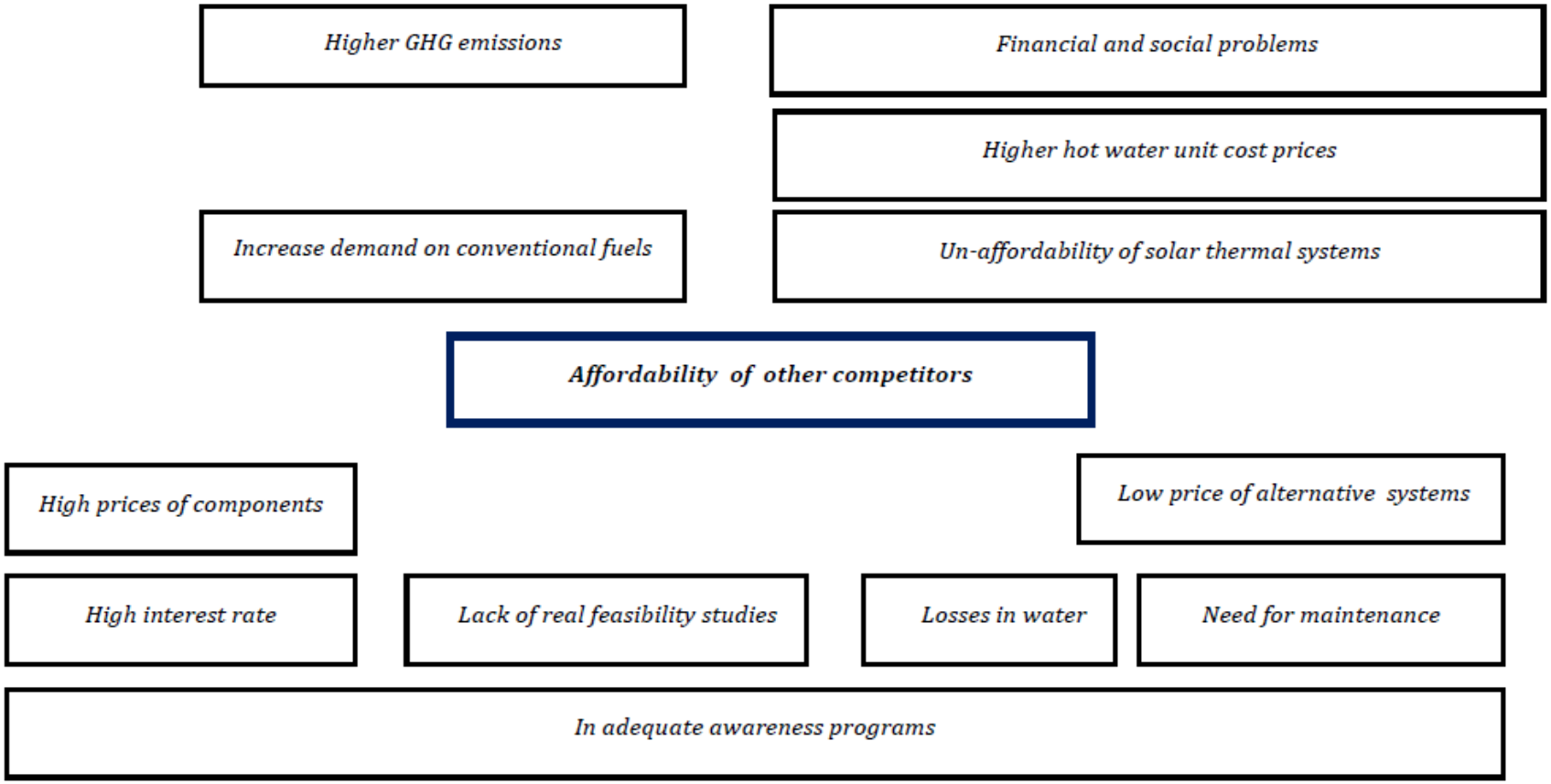
ANNEX 3 A-2: Problem tree for the Solar pumping technology



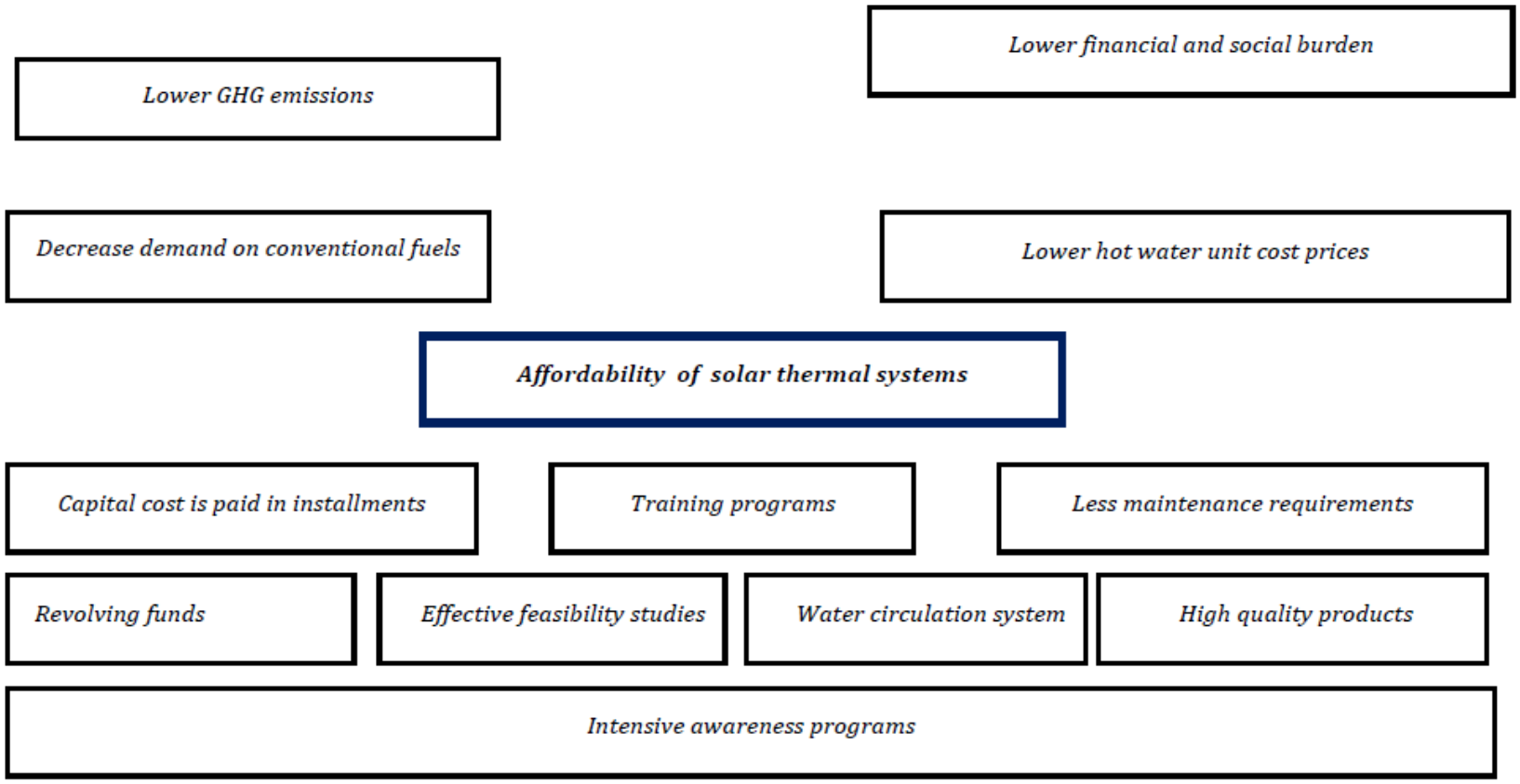
ANNEX 3 B: Objective tree for the Solar pumping technology



ANNEX 3 A-3: Problem tree for the Solar thermal technology

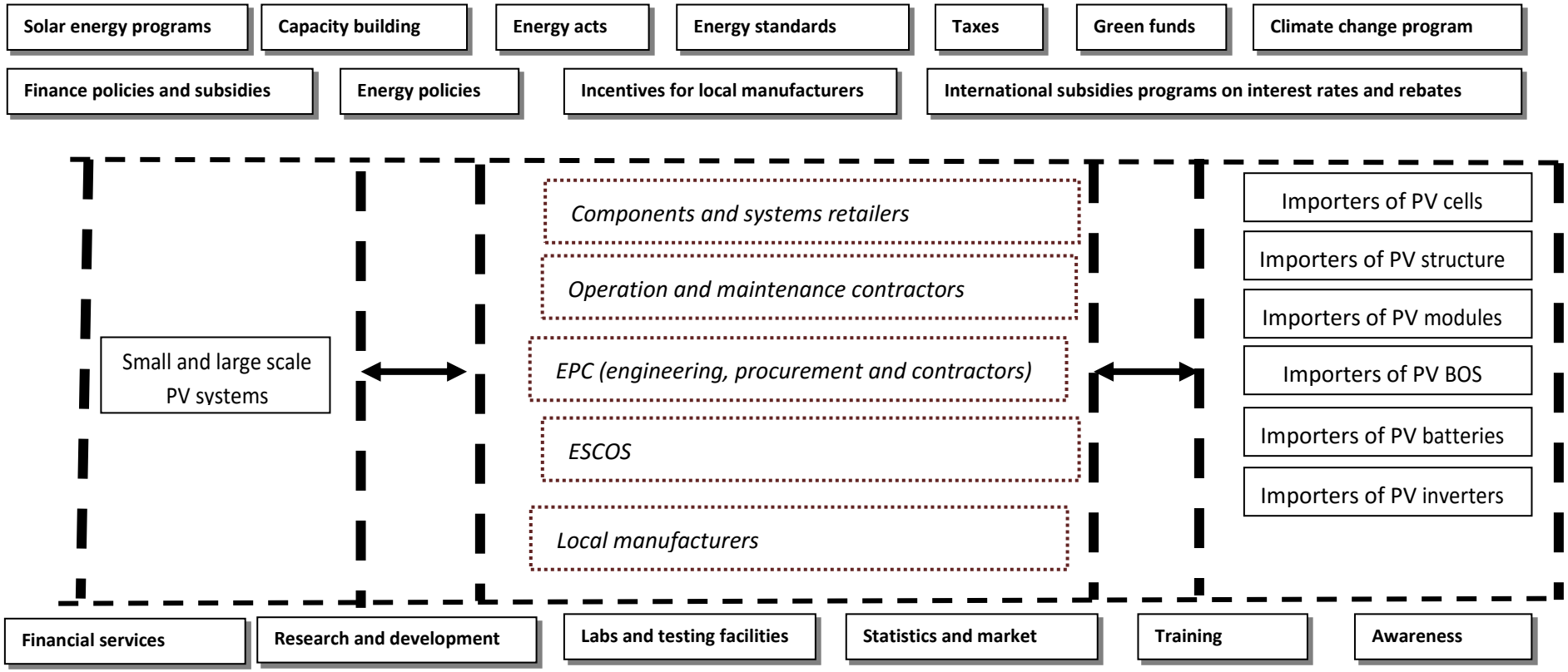


ANNEX 3 B-3: Objective tree for the Solar thermal technology



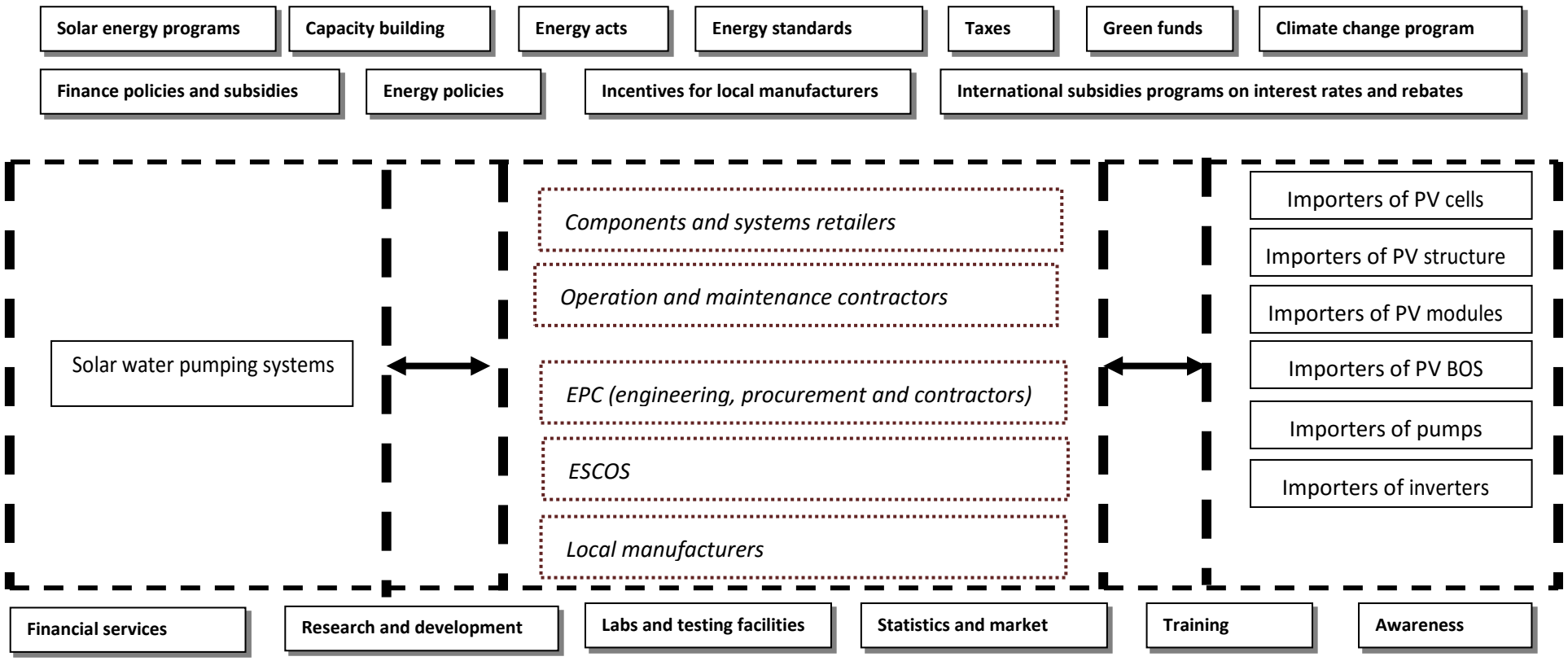
ANNEXES-3

Annex IA-1: Market Map for the Solar PV electrification, technology- Market Chain



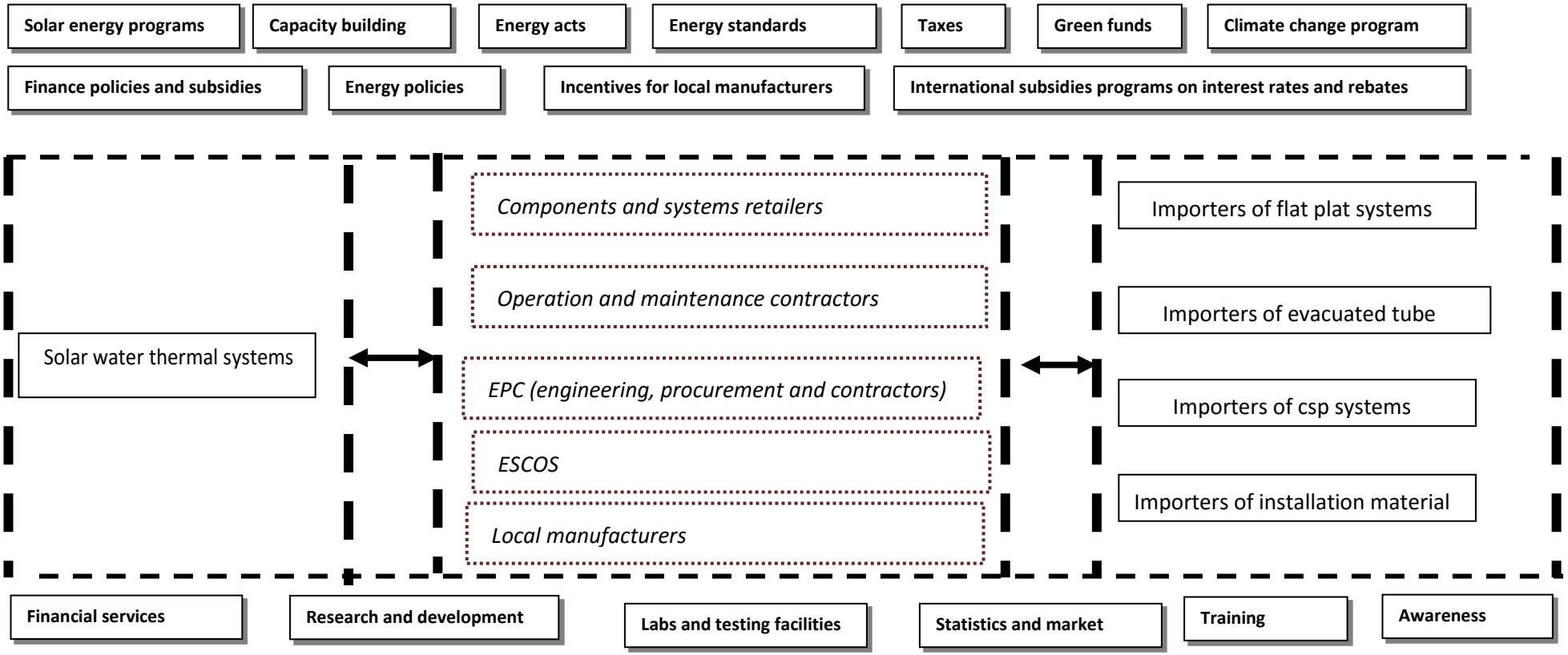
ANNEXES-3

Annex IA-2: Market Map for the Solar pumping technology- Market Chain

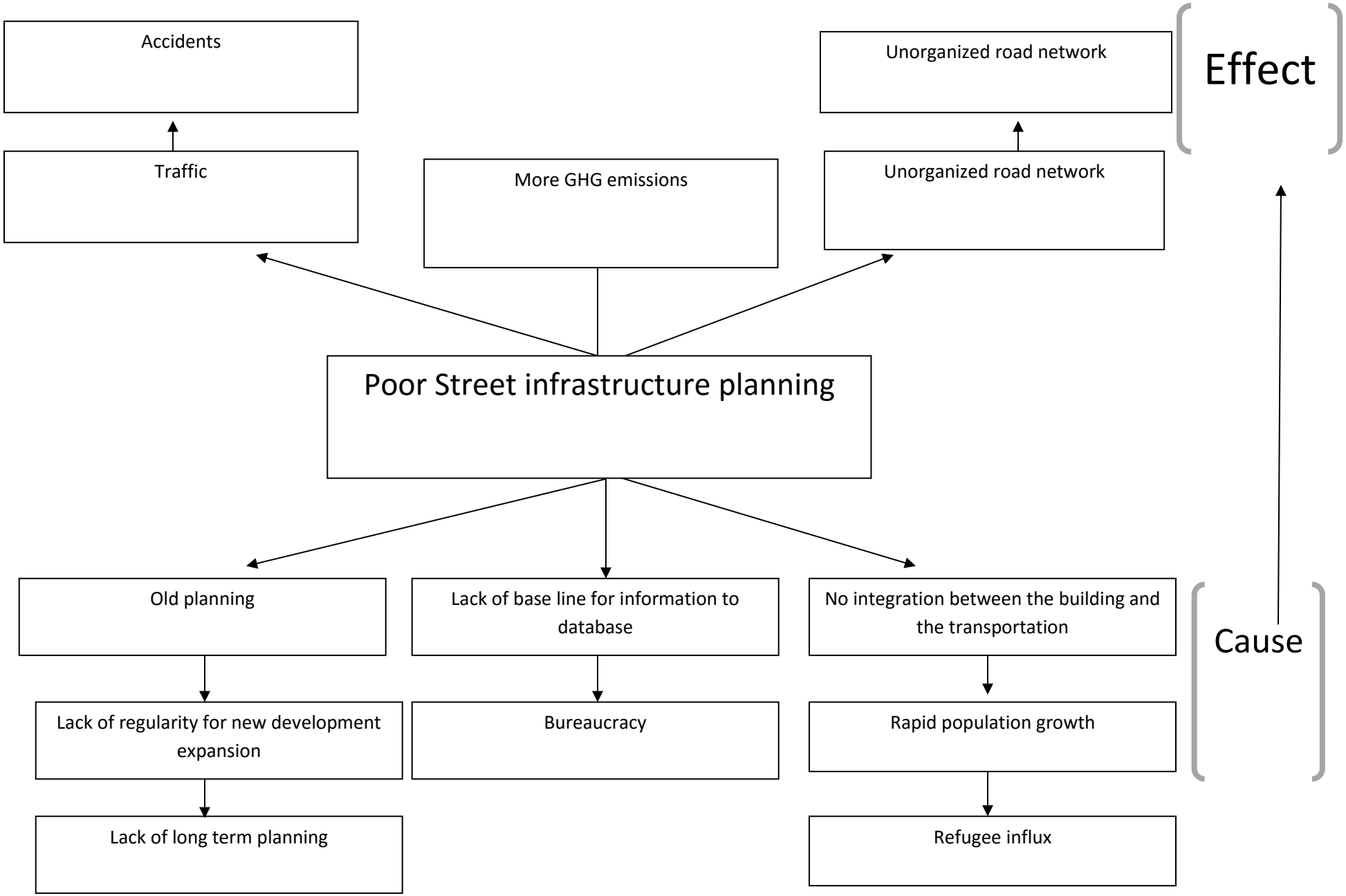


ANNEXES-3

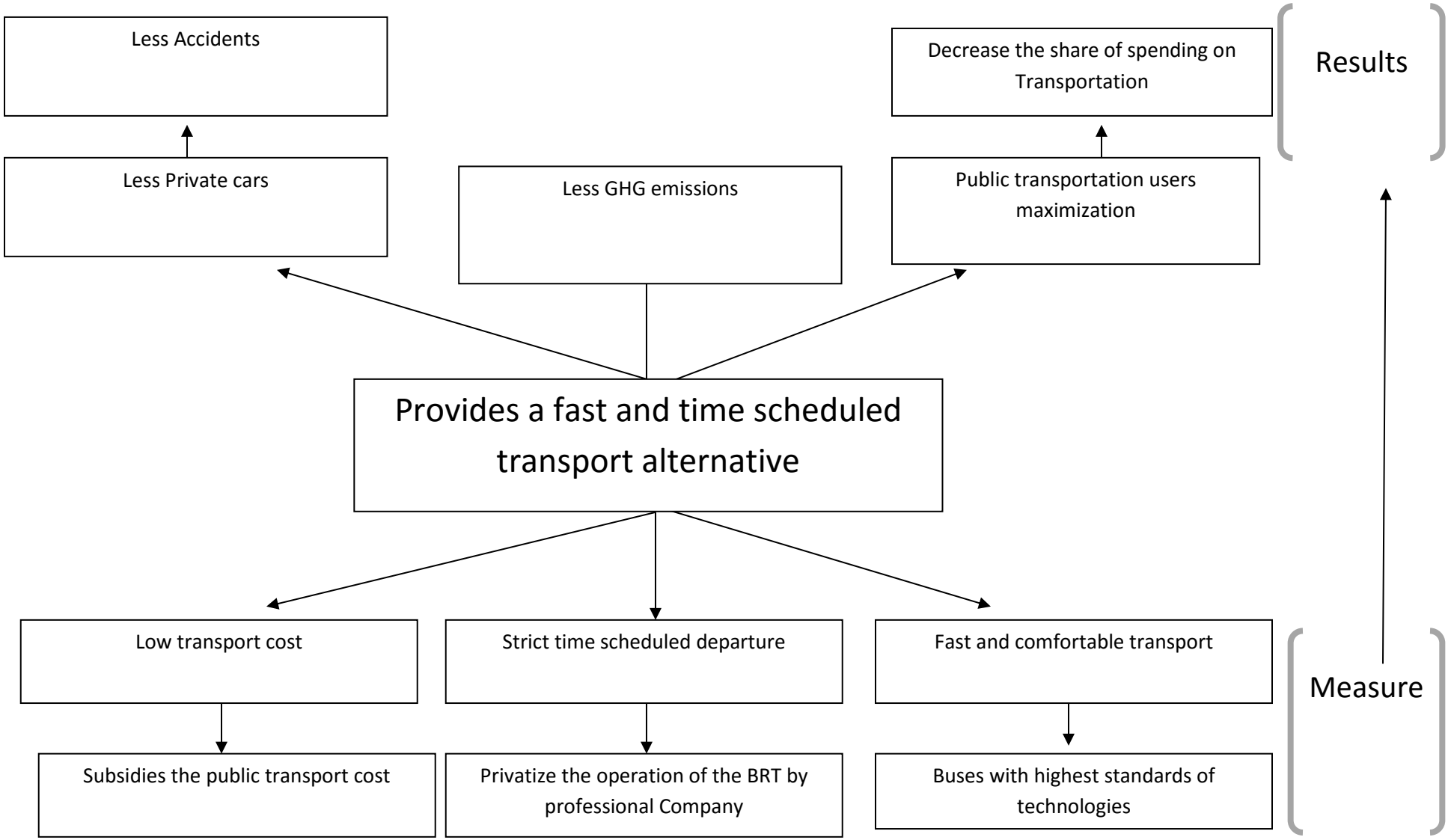
Annex IA-3: Market Map for the Solar thermal technology- Market Chain



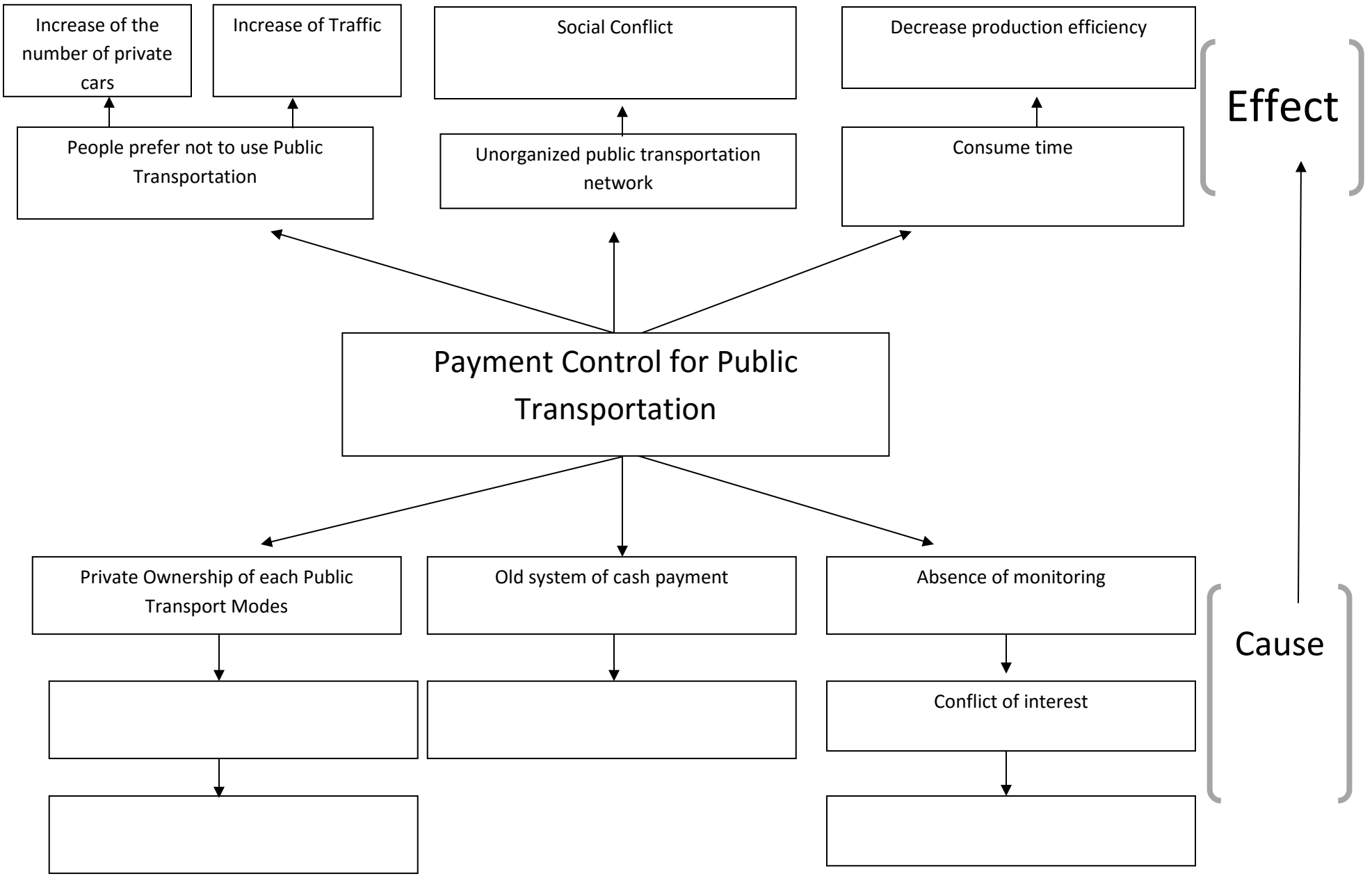
Problem Tree: Bus Rapid Transit



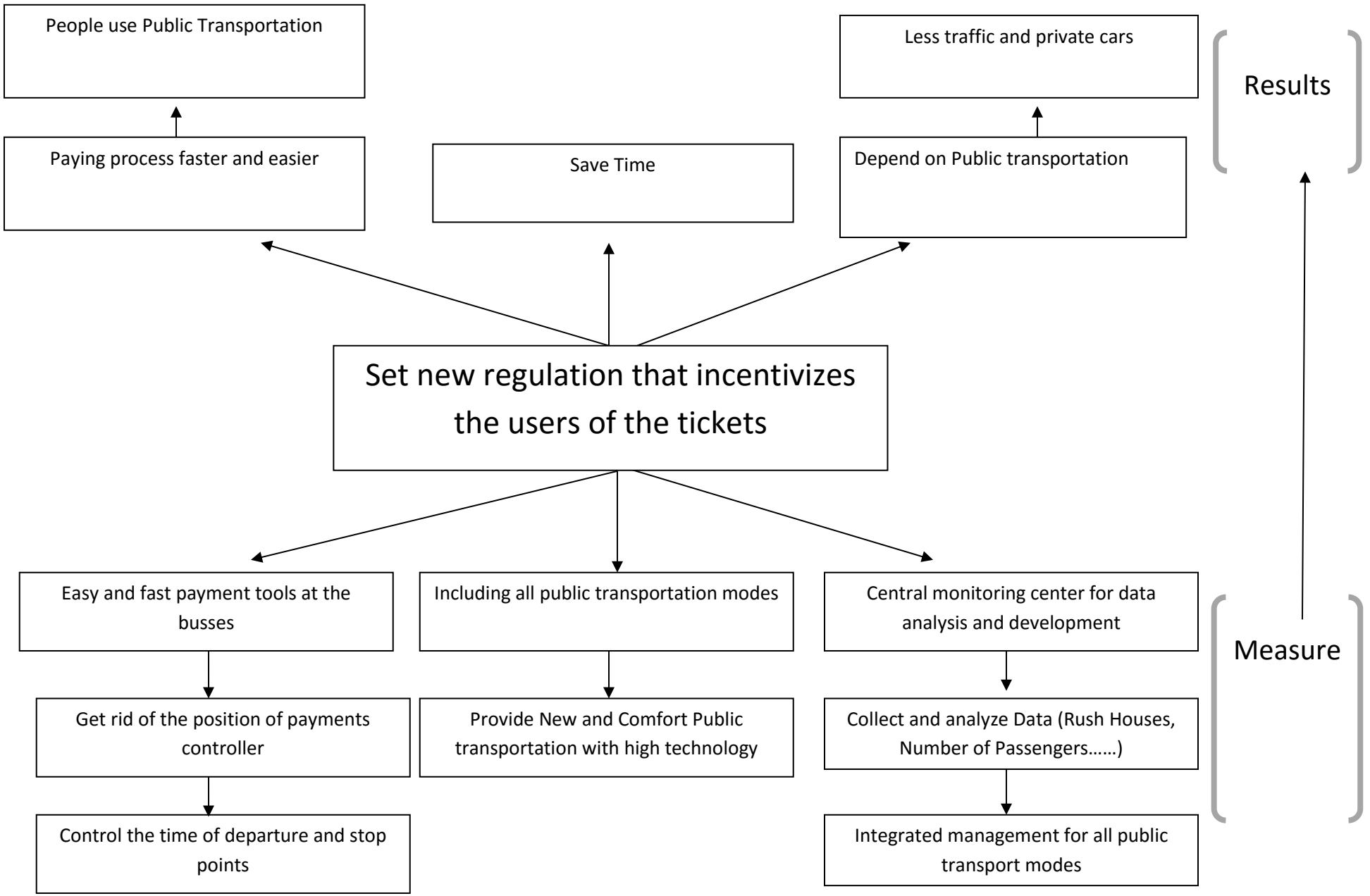
Measure Tree: Bus Rapid Transit



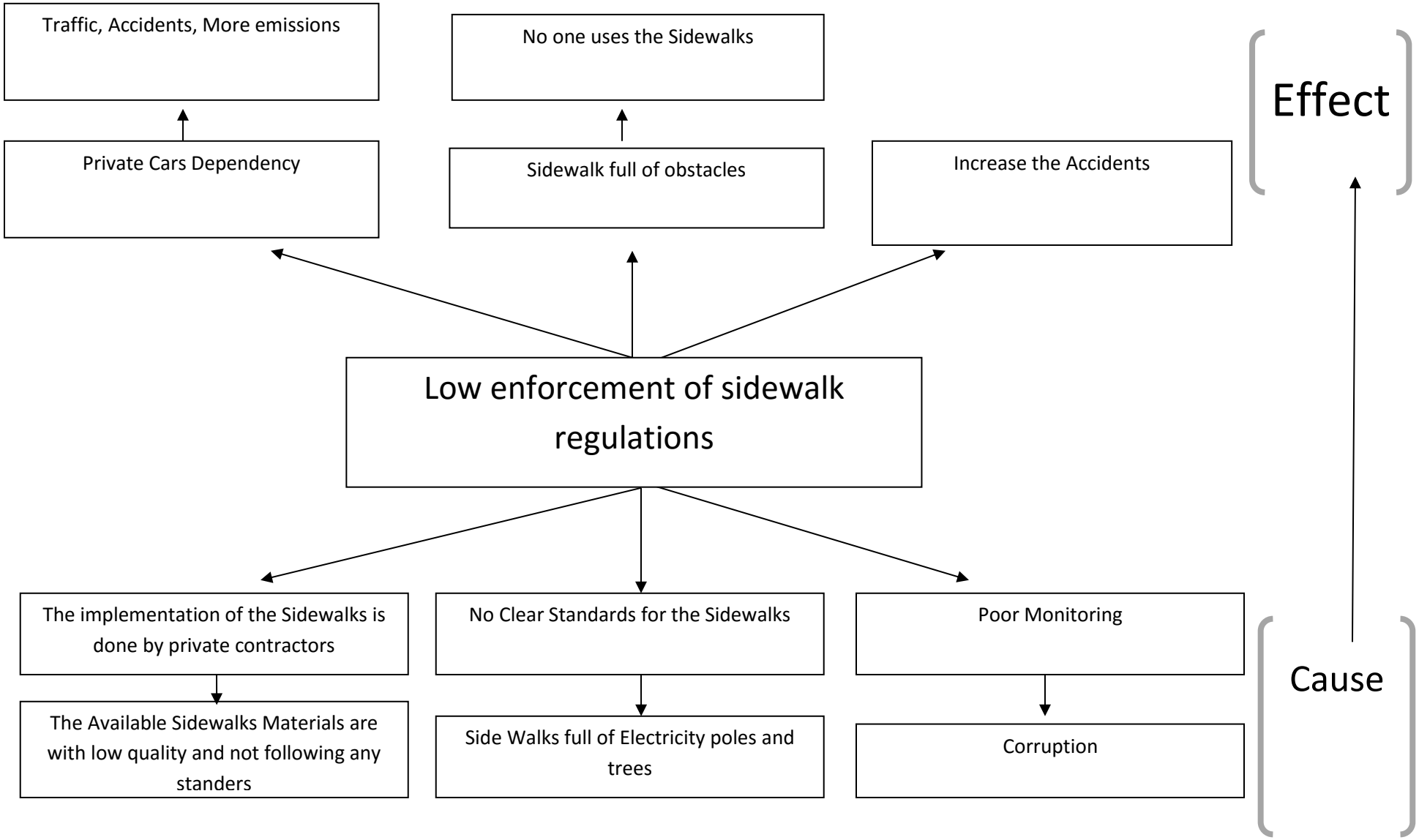
Problem Tree: Ticketing System



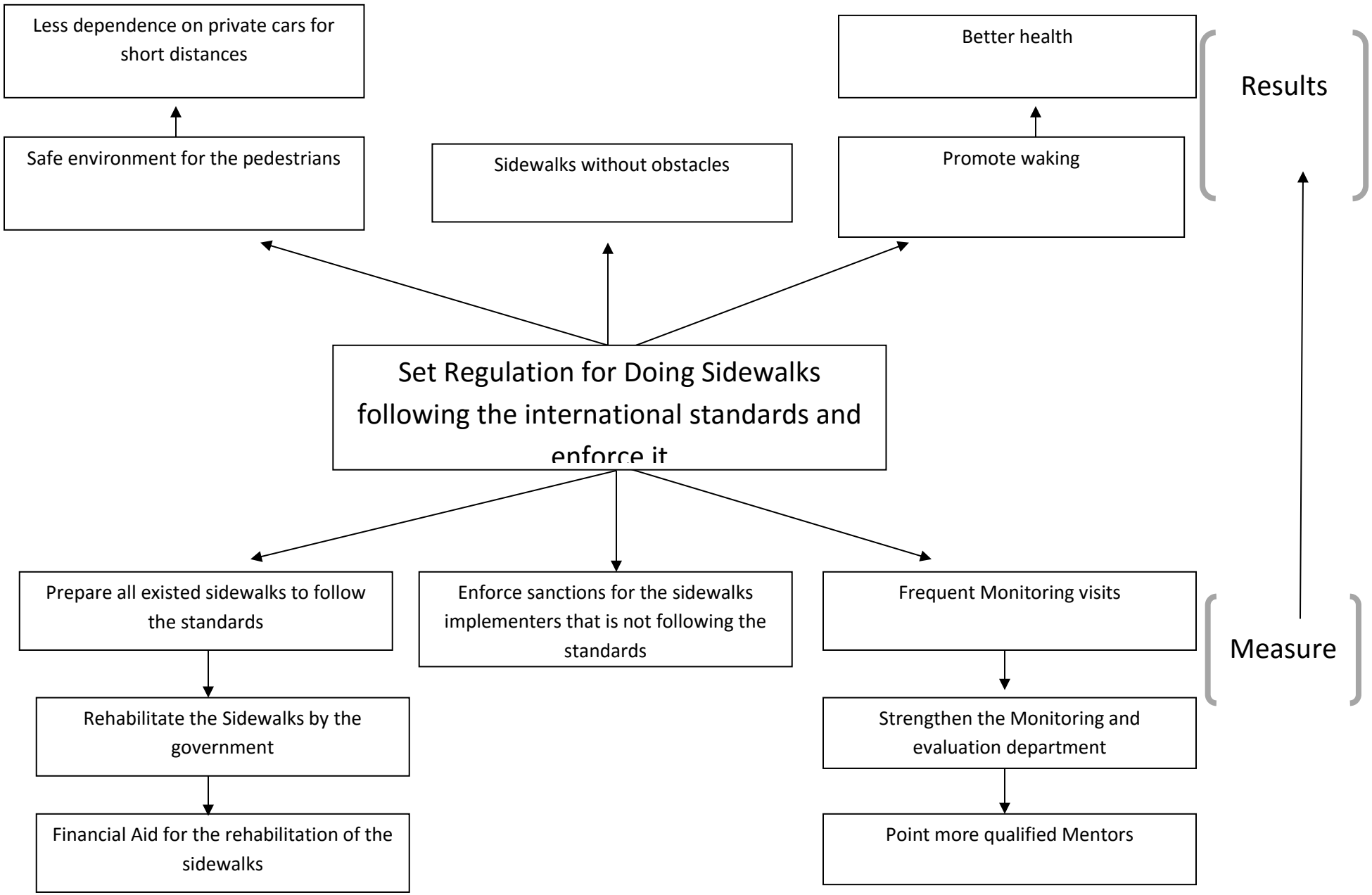
Measures Tree: Ticketing System

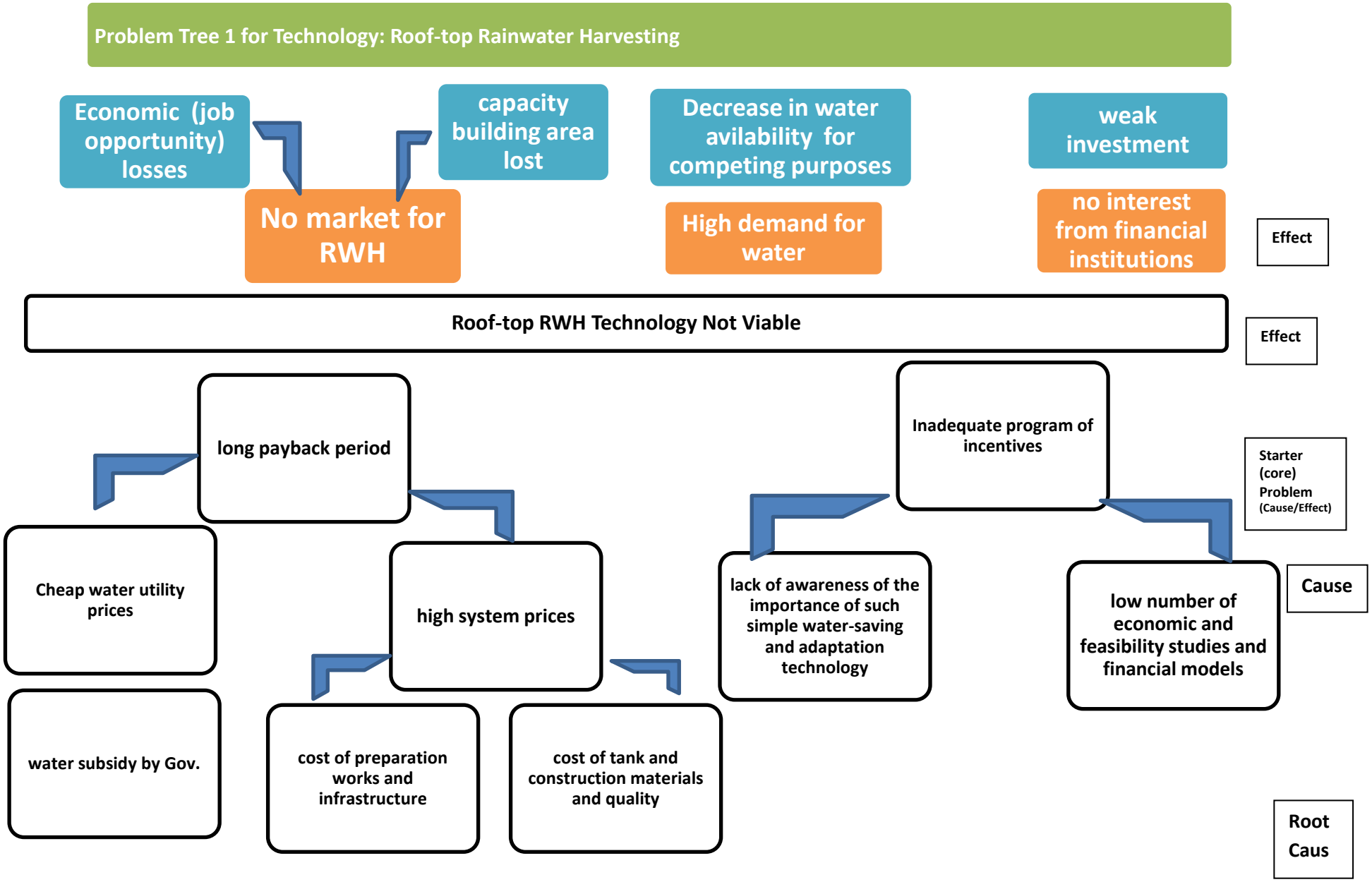


Problem Tree: Pedestrian infrastructure

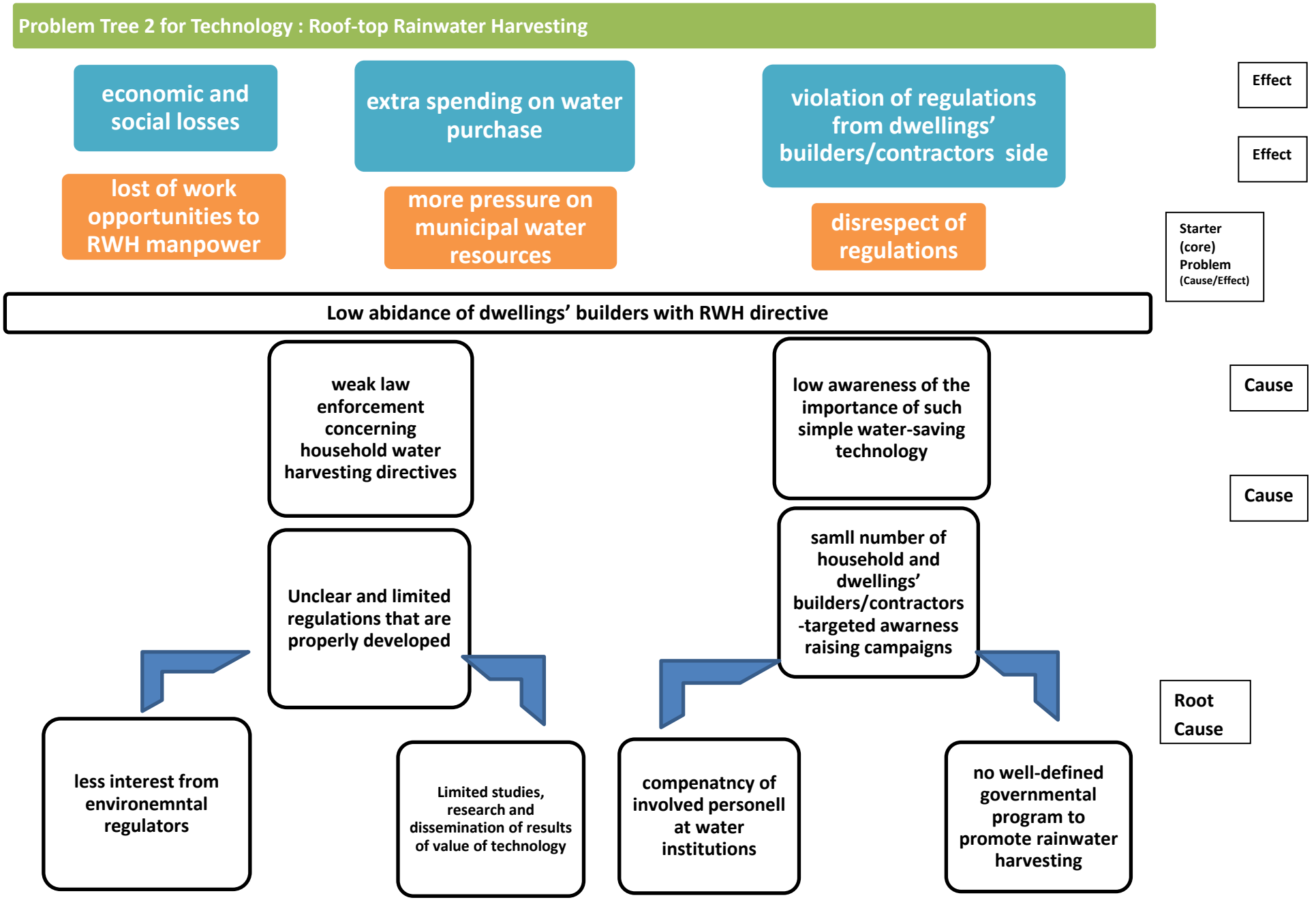


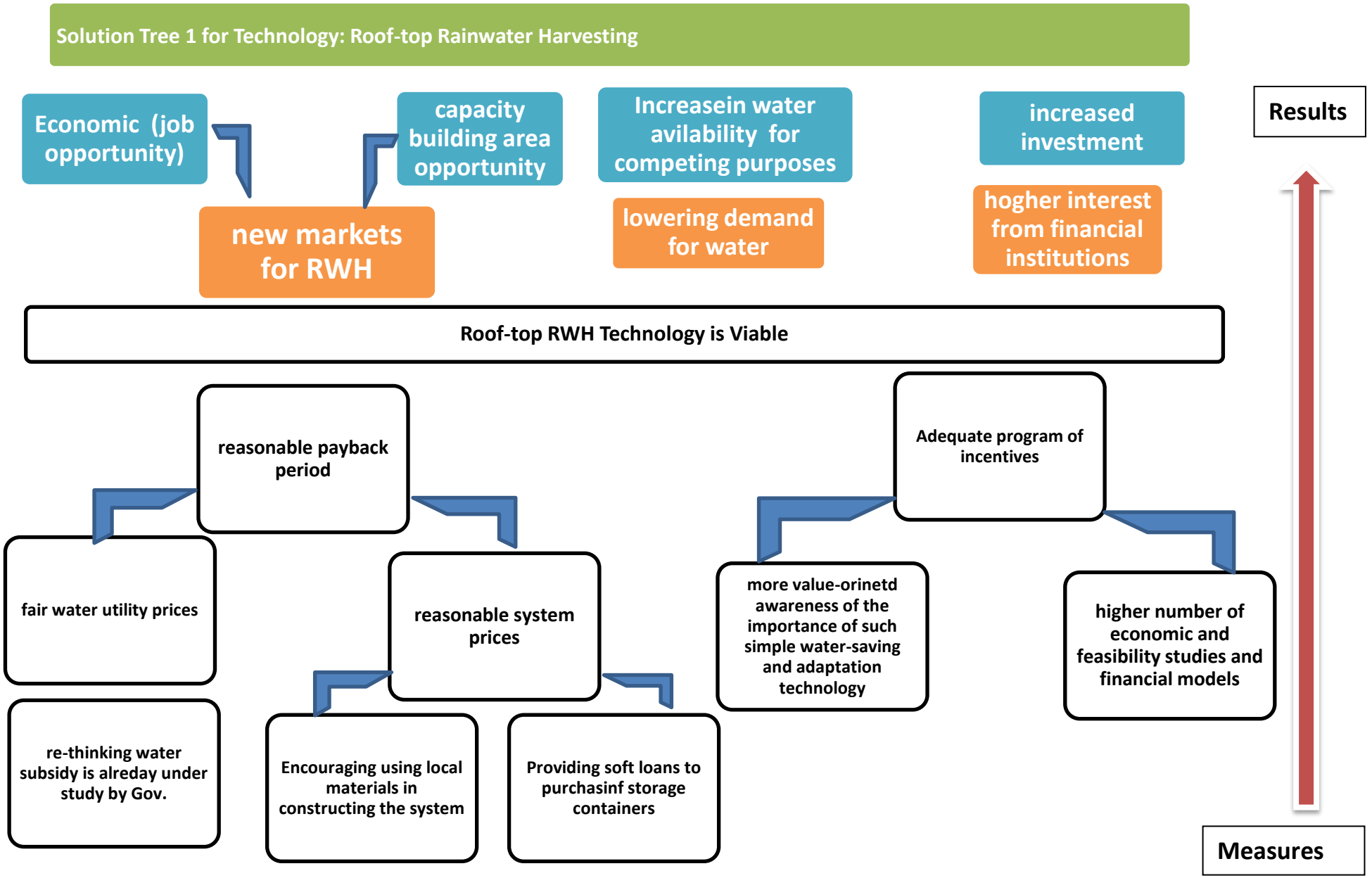
Measures Tree: Pedestrians infrastructure

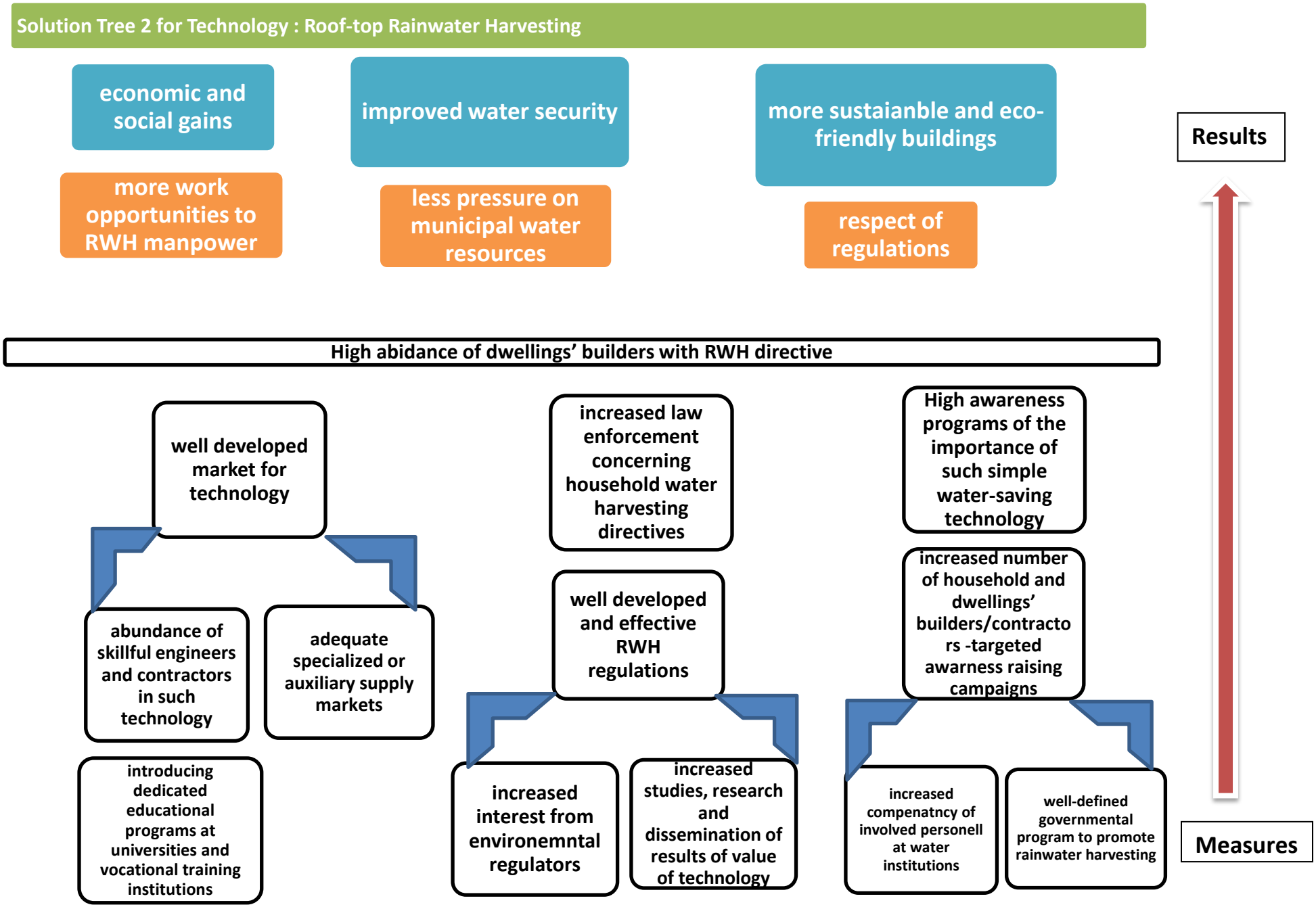



Problem Tree 1 for Technology: Roof-top Rainwater Harvesting
Economic (job opportunity) losses
capacity building area lost
Decrease in water avilability for competing purposes
weak investment
No market for RWH
High demand for water
no interest from financial institutions
Effect
Roof-top RWH Technology Not Viable
Effect
long payback period
Inadequate program of incentives
Starter (core) Problem (Cause/Effect)
Cheap water utility prices
high system prices
lack of awareness of the importance of such simple water-saving and adaptation technology
low number of economic and feasibility studies and financial models
Cause
water subsidy by Gov.
cost of preparation works and infrastructure
cost of tank and construction materials and quality
Root Caus

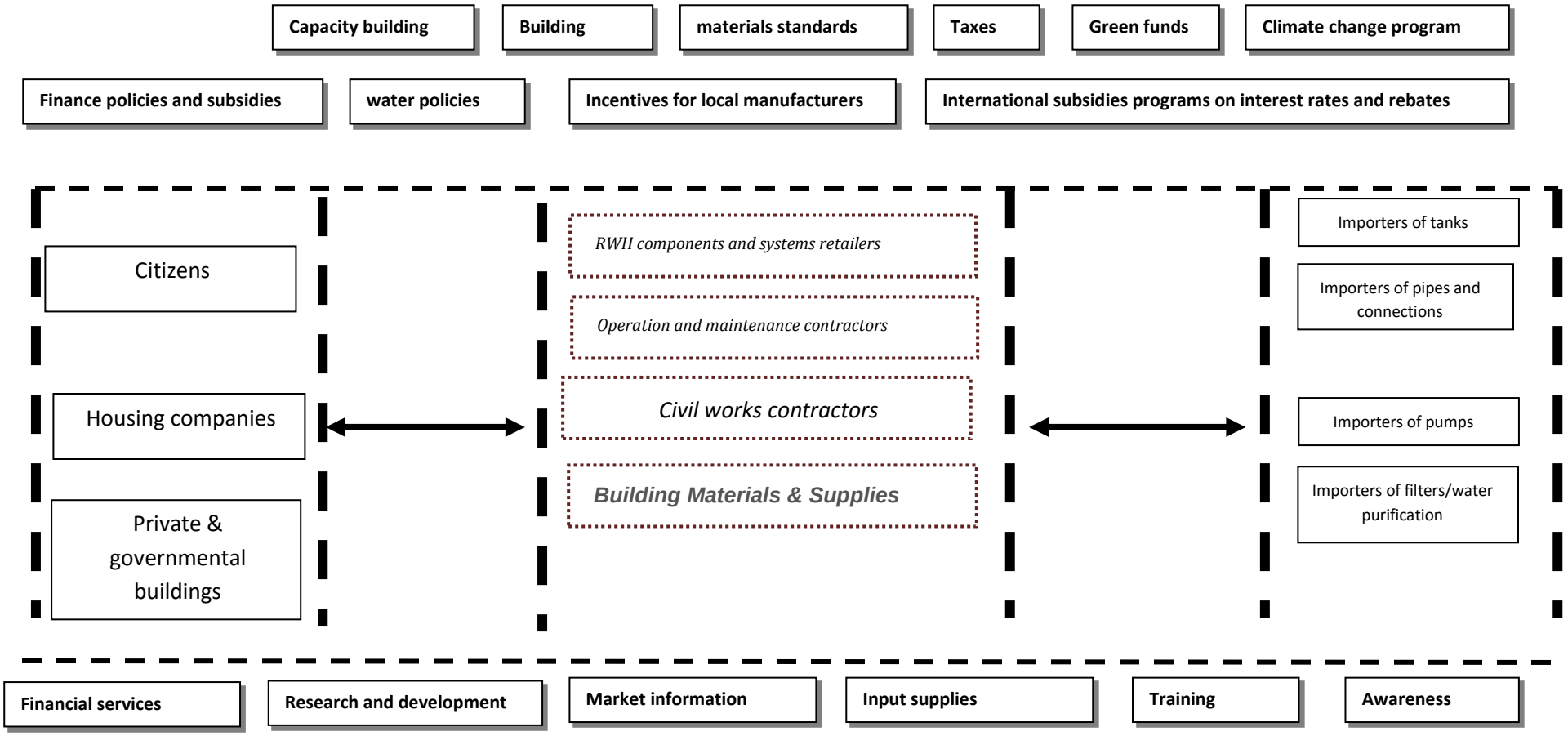
Annex 6: Water Sector's Solution Trees Technology: Roof-top Rain Water Harvesting




Solution Tree 1 for Technology: Roof-top Rainwater Harvesting
Economic (job opportunity)
capacity building area opportunity
Increasein water avilability for competing purposes
increased investment
Results
new markets for RWH
lowering demand for water
hogher interest from financial institutions
Roof-top RWH Technology is Viable
reasonable payback period
Adequate program of incentives
fair water utility prices
reasonable system prices
more value-orinetd awareness of the importance of such simple water-saving and adaptation technology
higher number of economic and feasibility studies and financial models
re-thinking water subsidy is alreday under study by Gov.
Encouraging using local materials in constructing the system
Providing soft loans to purchasinf storage containers
Measures


Solution Tree 2 for Technology : Roof-top Rainwater Harvesting
economic and social gains
improved water security
more sustaianble and eco-friendly buildings
more work opportunities to RWH manpower
less pressure on municipal water resources
respect of regulations
Results
High abidance of dwellings' builders with RWH directive
well developed market for technology
abundance of skillful engineers and contractors in such technology
adequate specialized or auxiliary supply markets
introducing dedicated educational programs at universities and vocational training institutions
increased law enforcement concerning household water harvesting directives
well developed and effective RWH regulations
increased interest from environemntal regulators
increased studies, research and dissemination of results of value of technology
High awareness programs of the importance of such simple water-saving technology
increased number of household and dwellings' builders/contractors -targeted awarness raising campaigns
increased compenatncy of involved personell at water institutions
well-defined governmental program to promote rainwater harvesting
Measures

3. Market Mapping for Roof-top Rainwater Harvesting



Problem Tree for Technology : Desalination/Brackish Water Treatment and Re-use

Effect

- no market for desalination technology
- high workforce cost
- less interest in the technology

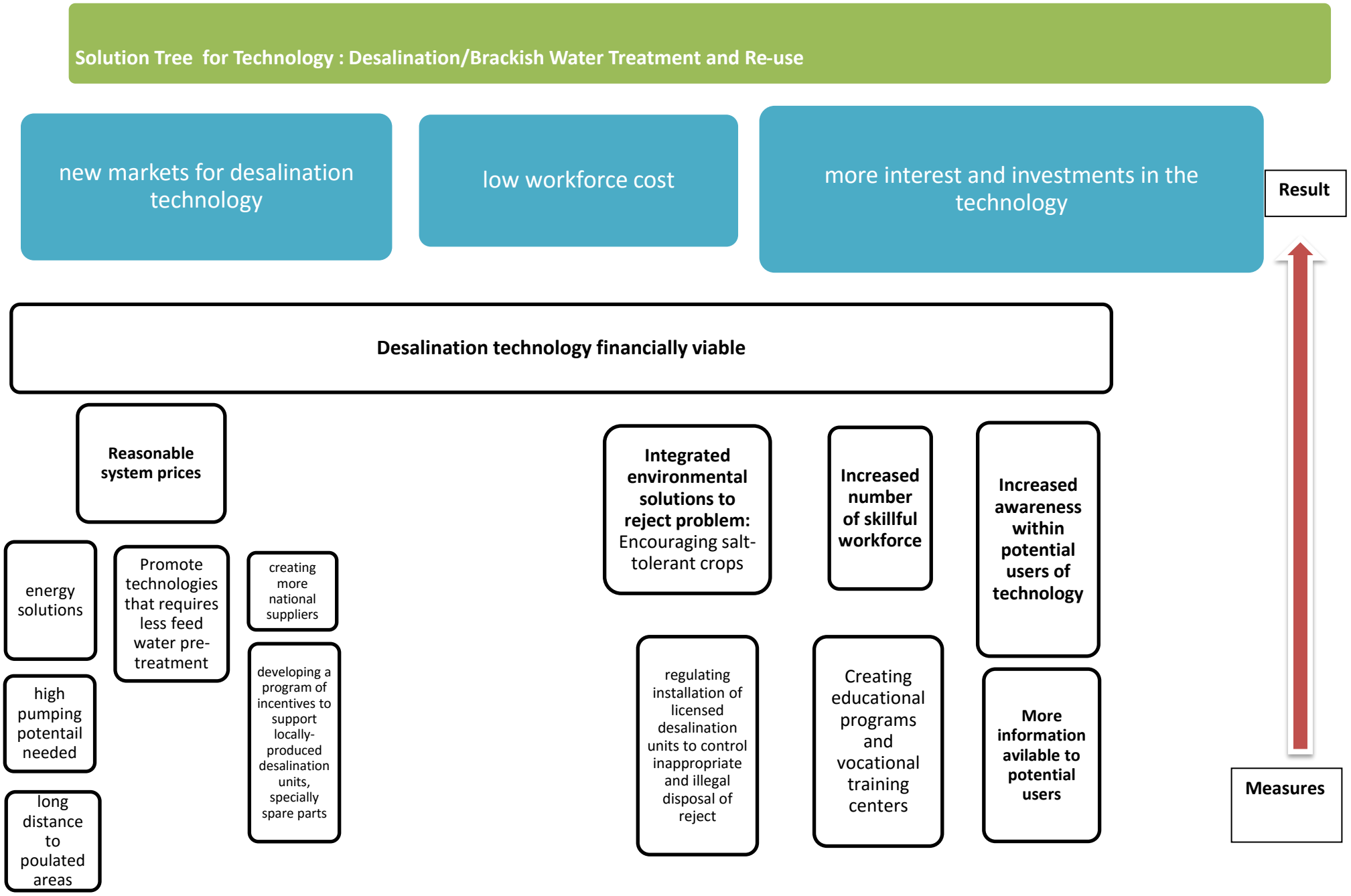
Starter (core) Problem (Cause/Effect)

Desalination technology financially not viable

Cause

- **High system prices**
  - large energy demands
  - high pumping potentail needed
  - long distance to poulated areas
  - need to treat some chemicals
  - few national suppliers
  - Absence of incentives to support locally-produced desalination units, specially spare parts
- **Enviroenmntal treatment cost**
  - Absence of directives to regulate installation of licensed desalination units to control inappropriate and illegal disposal of reject
- **Lack of enough skillful workforce**
  - limited educational programs and vocational training centers
- **low awareness within potential users of technology**
  - limited information avilable to potential users

Root Caus


Solution Tree for Technology : Desalination/Brackish Water Treatment and Re-use
new markets for desalination technology
low workforce cost
more interest and investments in the technology
Result
Desalination technology financially viable
Reasonable system prices
energy solutions
high pumping potentail needed
long distance to poulated areas
Promote technologies that requires less feed water pre-treatment
creating more national suppliers
developing a program of incentives to support locally-produced desalination units, specially spare parts
Integrated environmental solutions to reject problem: Encouraging salt-tolerant crops
regulating installation of licensed desalination units to control inappropriate and illegal disposal of reject
Increased number of skillful workforce
Creating educational programs and vocational training centers
Increased awareness within potential users of technology
More information avilable to potential users
Measures

Problem Tree 1 for Technology : Empowerment and expansion of WUAs

Effect

- Water losses
- economic losses
- less energized WUAs and Competitiveness deficiency

Starter (core) Problem (Cause/Effect)

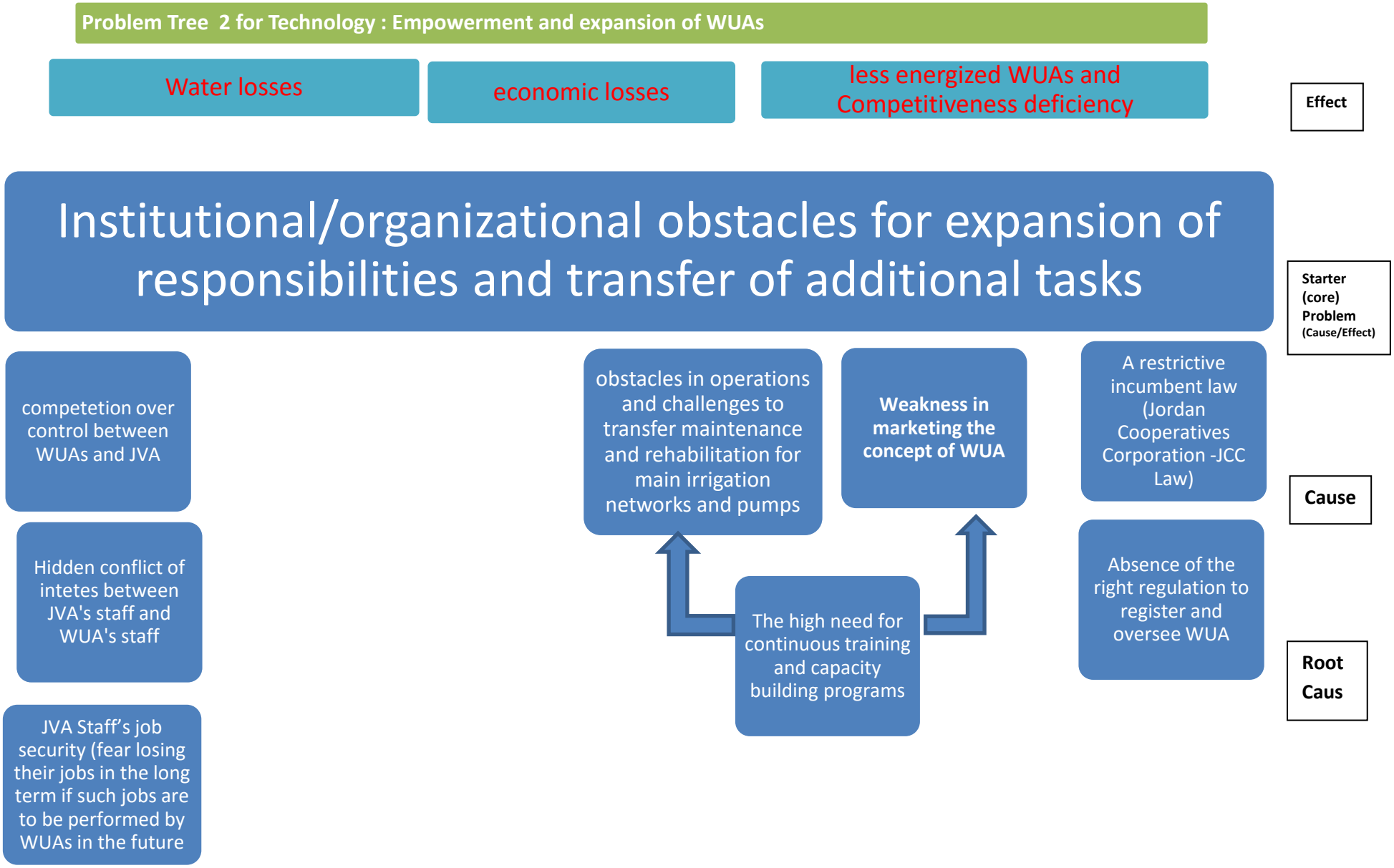
- Weak financial sustainability of such highly needed organizations

Cause

- limited finance for instance to rehabilitate the irrigation network
- weakness of marketing and competitive abilities of framers' products
- Financial deficiency in the Task Transfer Agreement (TTA) contracts
- inability to recover water costs

Root Caus

- Central Problem with incumbent law (Jordan Cooperatives Corporation -JCC Law)
- limited ability to develop income-generating projects
- TTAs include only limited amounts to cover other fixed and variable WUA costs
- weaknes in managment and financial skills


Problem Tree 2 for Technology : Empowerment and expansion of WUAs
Water losses
economic losses
less energized WUAs and Competitiveness deficiency
Effect
Institutional/organizational obstacles for expansion of responsibilities and transfer of additional tasks
Starter (core) Problem (Cause/Effect)
competetion over control between WUAs and JVA
Hidden conflict of intetes between JVA's staff and WUA's staff
JVA Staff's job security (fear losing their jobs in the long term if such jobs are to be performed by WUAs in the future
obstacles in operations and challenges to transfer maintenance and rehabilitation for main irrigation networks and pumps
Weakness in marketing the concept of WUA
A restrictive incumbent law (Jordan Cooperatives Corporation -JCC Law)
Cause
The high need for continuous training and capacity building programs
Absence of the right regulation to register and oversee WUA
Root Caus

Solution Tree 1 for Technology : Empowerment and expansion of WUAs

Water saving | economic gains | energized WUAs and strong competitiveness

Result

Strong financial sustainability of WUAs

Increase finance for instance to rehabilitate the irrigation network

- Suupport ammendment to legislative changes to incumbent law (Jordan Cooperatives Corporation - JCC Law) through developing a holistic responsive law for WUAs
- build ability to develop income-generating projects

Build capacity of marketing and competitive abilities of framers' products

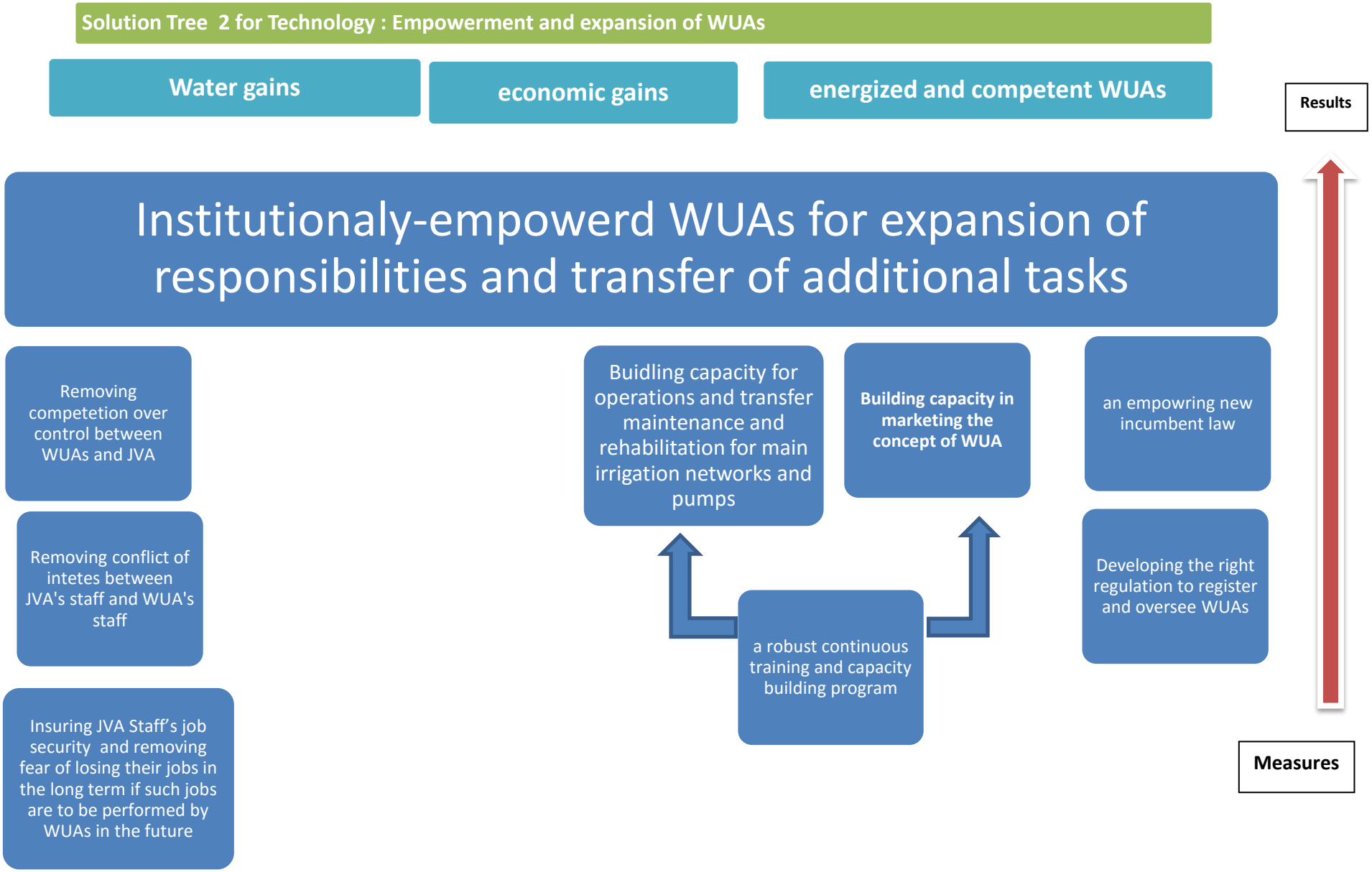
Remove deficiency in the Task Transfer Agreement (TTA) contracts

- TTAs to include all amounts neded to cover other fixed and variable WUA costs

increase ability to recover water costs

- stregnthen managment and financial skills and empower WUAs' overall financial and administrative systems

Measures


Solution Tree 2 for Technology : Empowerment and expansion of WUAs
Water gains
economic gains
energized and competent WUAs
Results
Institutionaly-empowerd WUAs for expansion of responsibilities and transfer of additional tasks
Removing competetion over control between WUAs and JVA
Removing conflict of intetes between JVA's staff and WUA's staff
Insuring JVA Staff's job security and removing fear of losing their jobs in the long term if such jobs are to be performed by WUAs in the future
Buidling capacity for operations and transfer maintenance and rehabilitation for main irrigation networks and pumps
Building capacity in marketing the concept of WUA
a robust continuous training and capacity building program
an empowring new incumbent law
Developing the right regulation to register and oversee WUAs
Measures

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A photo of the post-it note papers from market mapping consultation session/Water Sector

COST MATRIX					
Unit	US$	US$	US$	US$	
Costs	Cost 1	0	Cost 3	Cost 4	
Variable Name	***Capital***	***Operating***	***Maintenance***	***Intallation/training***	***Total Annual Costs (US$)***
Year 1	4150	50	50	0	**4250.00**
Year 2	0	50	50	0	**100.00**
Year 3	0	50	50	0	**100.00**
Year 4	0	50	50	0	**100.00**
Year 5	0	50	50	0	**100.00**
Year 6	0	50	50	0	**100.00**
Year 7	0	50	50	0	**100.00**
Year 8	0	50	50	0	**100.00**
Year 9	0	50	50	0	**100.00**
Year 10	0	50	50	0	**100.00**
					5,150
					Cost

BENEFIT MATRIX			
Unit	US$	US$	***Total Annual Benefits (US$)***
Benefits/Profit	Benefit 1	Benefit 2	
	Propirty tax cut	***Drink water saved***	
Year 1	50	70	**120.00**
Year 2	50	70	**120.00**
Year 3	50	70	**120.00**
Year 4	50	70	**120.00**
Year 5	50	70	**120.00**
Year 6	50	70	**120.00**
Year 7	50	70	**120.00**
Year 8	50	70	**120.00**
Year 9	50	70	**120.00**
Year 10	50	70	**120.00**
			1,200
			Benefit

Benefit-cost **-3,950**

NPV- Rooftop rainwater harvesting-10 year investment

Year	*Net Benefits in US$*	*Discounted Net Benefits Flow in US$*			
		3%	4%	7%	10%
1	-4,130.00	-4,009.71	-3,971.15	-3,859.81	-3,754.55
2	20.00	18.85	18.49	17.47	16.53
3	20.00	18.30	17.78	16.33	15.03
4	20.00	17.77	17.10	15.26	13.66
5	20.00	17.25	16.44	14.26	12.42
6	20.00	16.75	15.81	13.33	11.29
7	20.00	16.26	15.20	12.45	10.26
8	20.00	15.79	14.61	11.64	9.33
9	20.00	15.33	14.05	10.88	8.48
10	20.00	14.88	13.51	10.17	7.71

Discount Rate	*Net Present Value in US$*
3%	**-3,858.52**
4%	**-3,828.17**
7%	**-3,738.03**
10%	**-3,649.84**

WAC- Rooftop rainwater harvesting-10 year investment

Weighted Average Cost of Capital			
	Proportion	***Rate***	***WACC***
Debt	40%	4.50%	**3%**
Equity	60%	2%	

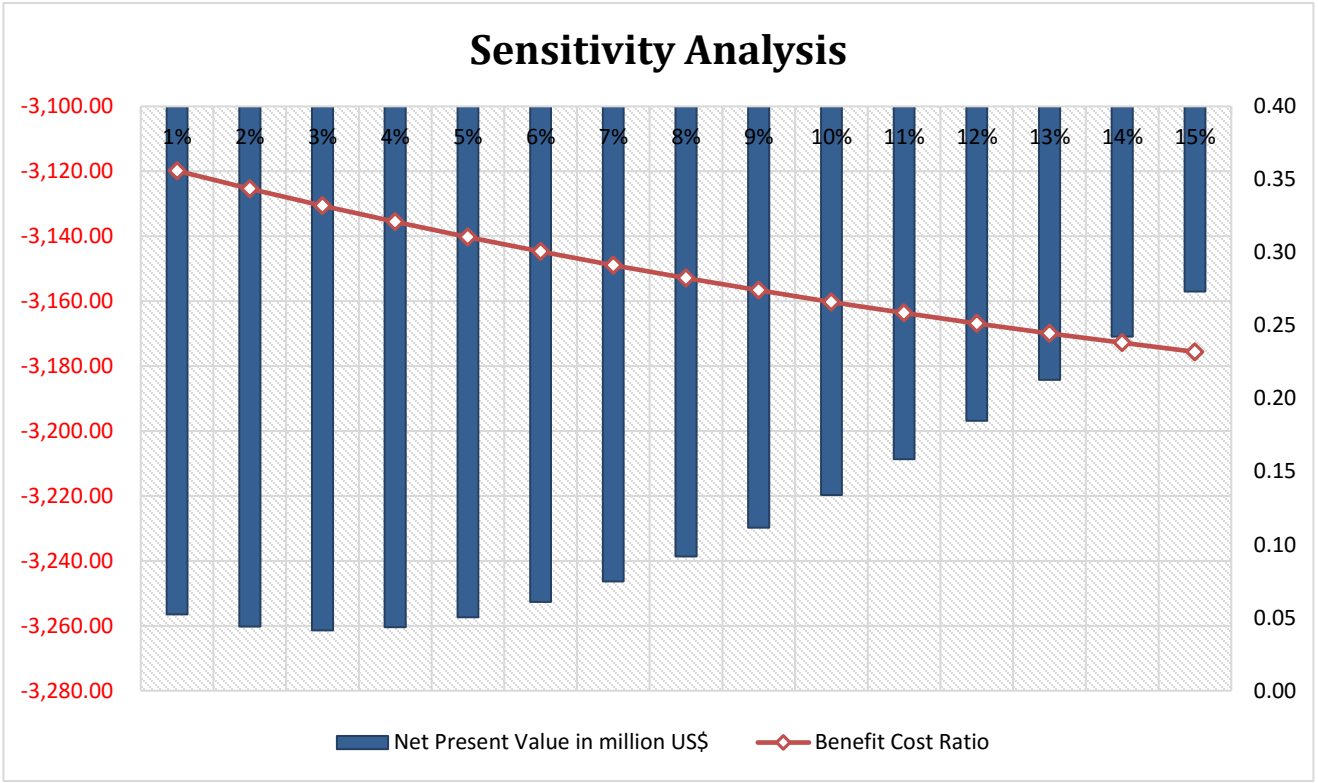
Weighted Average Cost of Capital			
	Proportion	***Rate***	***WACC***
Debt	30%	1.90%	**4%**
Equity	70%	4.90%	

Weighted Average Cost of Capital			
	Proportion	***Rate***	***WACC***
Debt	50%	7%	**7%**
Equity	50%	7%	

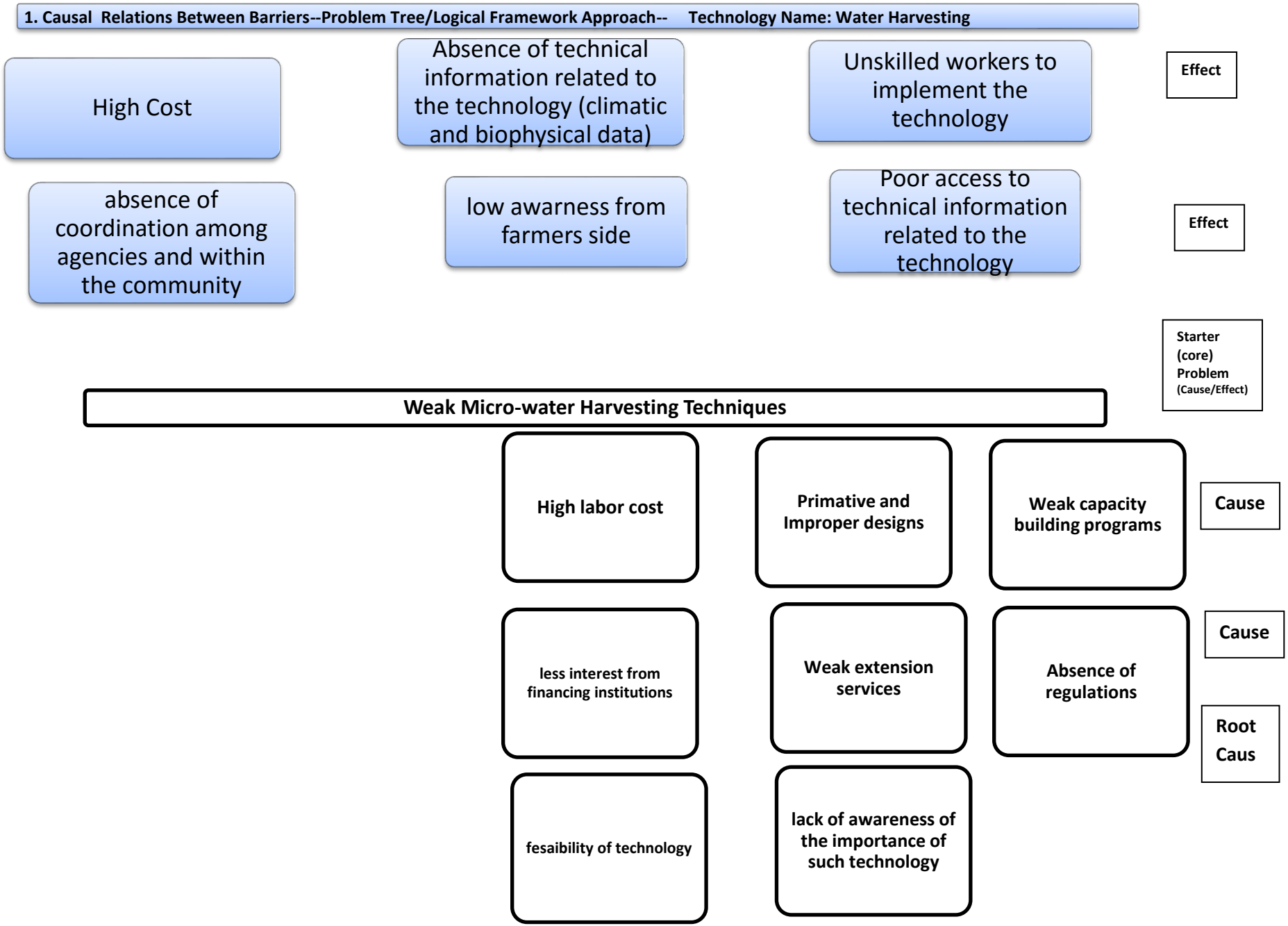
Weighted Average Cost of Capital			
	Proportion	***Rate***	***WACC***
Debt	70%	10%	**10%**
Equity	30%	10%	

Sensitivity Analyses: **Rooftop rainwater harvesting-10 year investment**

Net Present Value in million US$	*Benefit Cost Ratio*
-3,919.48	0.22
-3,888.98	0.22
-3,858.52	0.21
-3,828.17	0.20
-3,797.95	0.20
-3,767.89	0.19
-3,738.03	0.18
-3,708.39	0.18
-3,678.99	0.17
-3,649.84	0.17
-3,620.95	0.16
-3,592.35	0.16
-3,564.04	0.15
-3,536.03	0.15
-3,508.32	0.15



Annex 7: Agriculture Sector Problem Tree, Solution Tree and Market Mapping for priority technologies



2. Solution Tree: Trabslating Barriers into measures--Logical Framework Approach-- Technology Name: Water Harvesting

Less cost

Better Access to information related to the technology

Availability of technical information related to the technology (climatic and biophysical data

Results (outcomes)

Better coordination among agencies and within the community

higher awarness from farmers side

skilled workers to implement the technology

Results (outcomes)

Weak Micro-water Harvesting Techniques

Starter (core) Problem (Effect)

Governmental/organizations' incentives or direct monetary support

Establish co-operatives to reduce the overhead cost

Collect information and material related to the technology and disseminate to farmers

develop capacity building program

Apply for grants to finance the technology

awareness and outreach programs

Improve extension services

Measures

Measures

1. Causal Relations Between Barriers--Problem Tree/Logical Framework Approach-- Technology Name: Support of Water Saving Technologies

High Cost

Weak extension and lack of coordination

Unskilled workers to implement the technology

Effect

No clear Regulations and policies

Absence of standards and quality control

Poor access to technical information related to the technology

Effect

Starter (core) Problem (Cause/Effect)

Poor operation and maintainance

High initial cost

Absence of proper training on operation and Maintainance

Weak capacity /unskilled labor

Cause

less interest from financing institutions

Weak extension services

Absence of regulations

Cause

fesaibility of technology

improper monitoring system

Root Caus

2. Solution Tree: Trabslating Barriers into measures--Logical Framework Approach-- Technology Name: Support of Water Saving technologies

Less cost/Affordable technology

Better Access to information related to the technology

Better extension services

Results (outcomes)

Better coordination among agencies and within the community

Develop standards and quality control measures

skilled workers to implement the technology

Results (outcomes)

Poor operation and maintainance

Starter (core) Problem (Effect)

Governmental/organizations' incentives or direct monetary support

Establish co-operatives to reduce the overhead cost

develop capacity building program

awareness and outreach programs

Improve extension services

Measures

Establish a coordination unit to oversee and monitor the proper implementation of the technology

Apply for grants to finance the technology

Measures

1. Causal Relations Between Barriers--Problem Tree/Logical Framework Approach-- Technology Name: Introducing plant varieties resistant to Climate Change

Weak access to financial sources for local farmers

low investment in infrastructure and technical capcities

lack of supportive mechanism (subsidy or any other incentives) to promote the technology

Effect

lack of financial support for research institutions (state and private)

Current capacity of research institutions is not up-to-date

low awarness from farmers side

Effect

Starter (core) Problem (Cause/Effect)

weak utilization of Plant Genetic Resources

Lack of Skilled Researchers and Technicians

Insufficient Research

High Cost

Cause

Infrastructure

no well-defined governmental program to promote the technology

Unclear regulations

Cause

Root Caus

Land Tenure

Farmers Limited Knowledge of the technology

2. Solution Tree: Translating Barriers into measures--Logical Framework Approach-- Technology Name: Introducing plant varieties resistant to Climate Change

Better investment

Better access to financial sources for local farmers

Introduction of supportive mechanism (subsidy/ incentives) to promote the technology

Results (outcomes)

Increase in Reserach Activities

Higher awarness from farmers side

Current capacity of research institutions is up-to-date

Results (outcomes)

Starter (core) Problem (Effect)

Maximized utilization of Plant Genetic Resources

Governmental/organizations' incentives or direct monetary support

Explore Funding potential and Resources

develop capacity building program

Establish a focal unit to coordintae reserach efforts

Revising and updating regulations and directives

Design awareness and outreach programs

Measures

A photo of the post-it note papers from market mapping consultation session/Agriculture Sector.