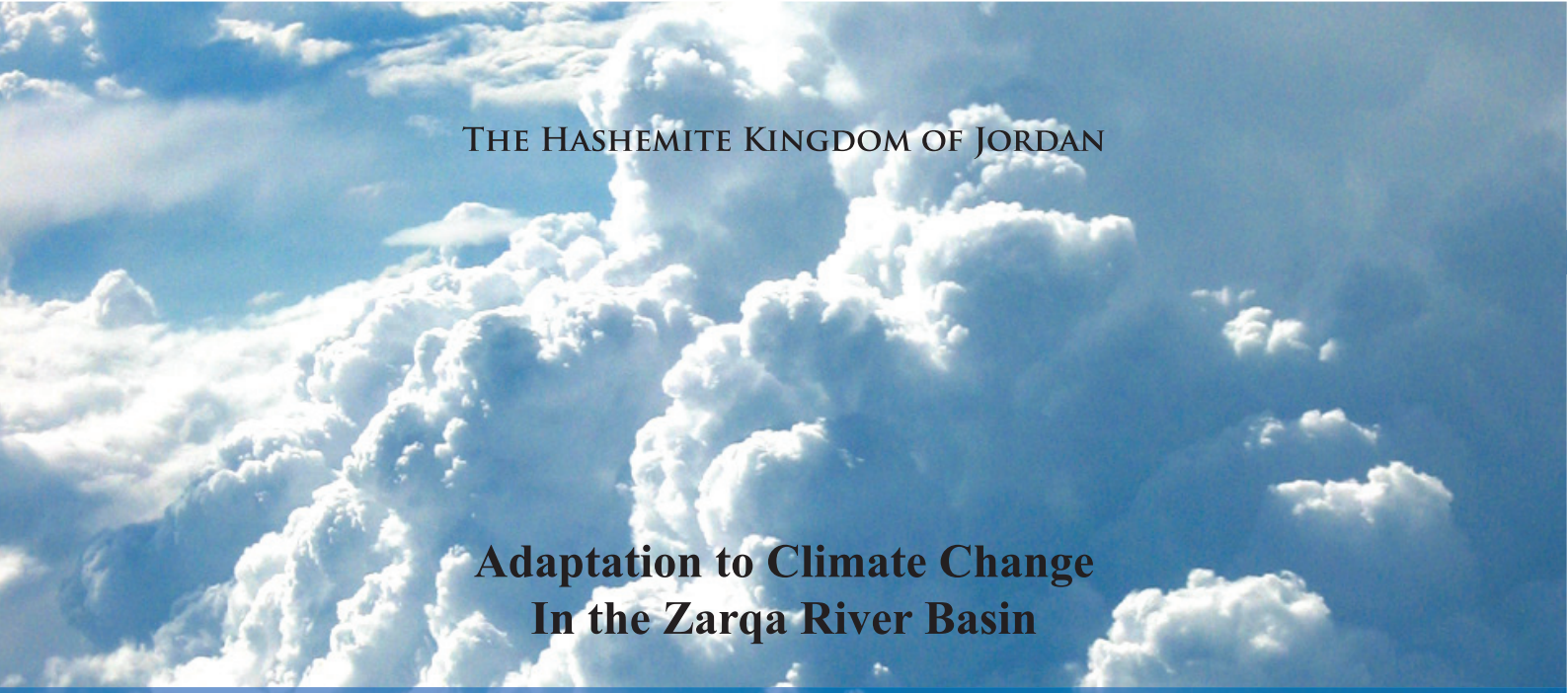

THE HASHEMITE KINGDOM OF JORDAN

Adaptation to Climate Change In the Zarqa River Basin

Guiding Manual For Identifying the Best Adaptation Options

MDG:F
MDG ACHIEVEMENT FUND

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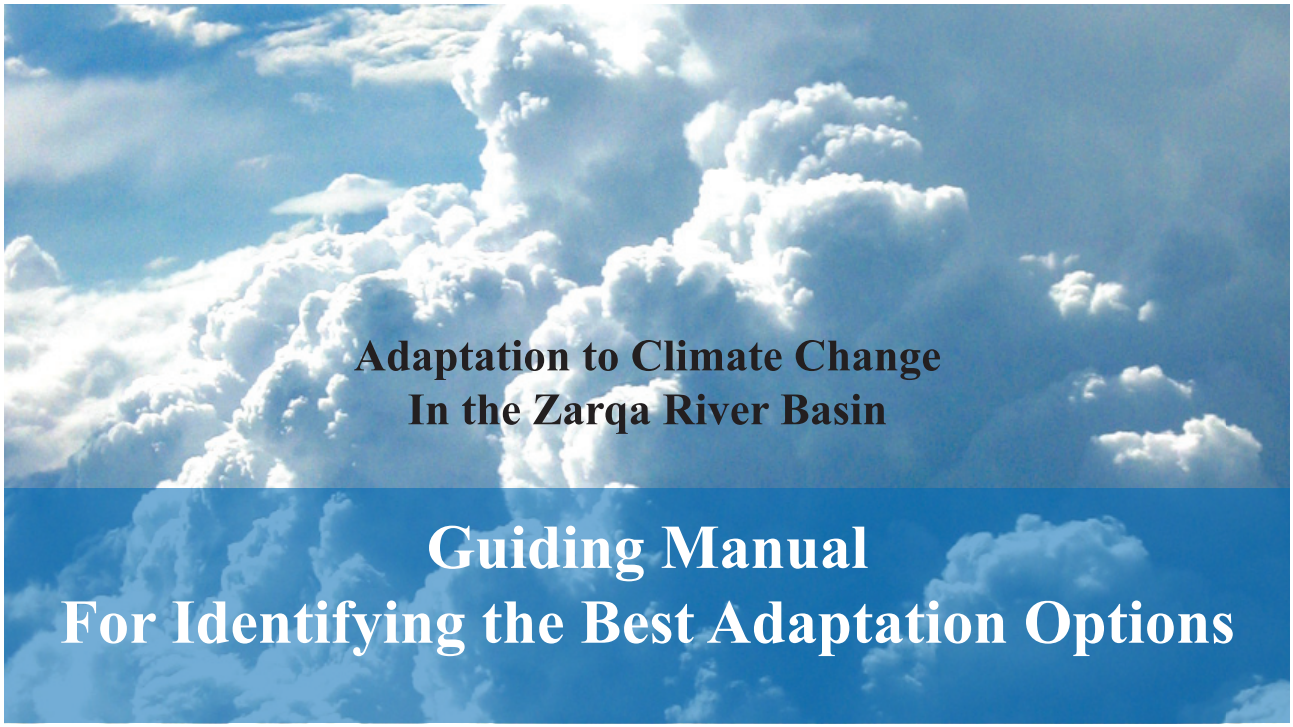

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The views expressed in this publication are those of the author and do not necessarily represent those of the United Nations Development Programme (UNDP), the report is the work of an independent team of authors sponsored by UNDP.

Foreword

Jordan is classified as one of the four most water scarce countries in the world. The National Agenda that sets Jordan's development vision till 2015, as well as the United Nations Development Assistance Framework (UNDAF) document (2008-2012), stress that Jordan's remarkable development achievements are under threat due to the crippling water scarcity, which is expected to be aggravated by Climate Change. The UNDAF (2008-2012) addresses four key related challenges to sustain progress towards the MDGs, which include: (i) water scarcity; (ii) drinking water supply security and quality; (iii) health, agriculture and food production vulnerability to Climate Change; and (iv) vulnerability of local biodiversity to Climate Change.

Jordan's Initial National Communication (INC) to the United Nations Framework Convention on Climate Change (UNFCCC) foresees that over the next three decades, Jordan will witness a rise in temperature, drop in rainfall, reduced ground cover, reduced water availability, heat-waves, and more frequent dust storms. The Second National Communication (SNC) to the UNFCCC identifies water as a priority area.

There are several barriers to water sector adaptation to Climate Change that threaten the sustainability of Jordan's achievement of the MDG targets, these include: (i) Climate Change risks not sufficiently taken into account within sectoral policies and investment frameworks; (ii) existing climate information, knowledge and tools are not directly relevant for supporting adaptation decisions and actions; and (iii) weak national capacity to develop sectoral adaptation responses. Jordan's success in adapting to increased water scarcity and related threats to health, food security, productivity, and human security induced by Climate Change is the key to sustaining its human development achievements and growth.

The government of Jordan represented by the Ministry of Planning and International Cooperation (MOPIC), the Ministry of Water and Irrigation (MWI), the Ministry of Health (MOH), the Ministry of Agriculture (MOA), and the Ministry of Environment (MoEnv) have been the implementing partner in carrying out the activities of the United Nations Country Team (UNCT) Joint programme (JP) on "Adaptation to Climate Change to Sustain Jordan's MDG Achievements" which is supported by a team of UN agencies in Jordan consisting of UNDP, UNESCO, WHO-CEHA, and FAO. The JP has worked on the identification of adaptation barriers and gaps have to be addressed, assessment of

the direct and indirect impacts of climate change on the health, nutrition, and livelihood security of people, screening and assessing potential adaptation strategies prior to wide scale application, and assessing and strengthening existing national adaptation capacities.

In addition to the key role of the JP to strengthen and develop the capacity of different institutions and communities in adaptation to Climate Change the JP is to disseminate the wealth of results, information, and studies accumulated during the period of its implementation to stakeholders, scientific and research community, and the public at large.

The component of the JP implemented by the MoEnv in cooperation with UNDP has been focusing on the Zarqa River Basin (ZRB) for its activities. The major activities of this component are: Identifying the direct and indirect impacts of Climate Change on the water sources of the ZRB, identifying barriers and opportunities for Climate Change adaptation in the basin, Developing a Climate Change adaptation programme for the basin, and pilot Climate Change intervention for groundwater protection on one local community in the basin.

This document is the result of a collaborative and joint efforts of many professionals from the government, private sectors, NGO's, and local community representatives to identify the appropriate adaptation measures, come up with tools for prioritization of adaptation to Climate Change interventions, and develop programmes to better adapt to Climate Change impacts for the ZRB towards strengthening the capacity of the basin to adapt with Climate Change impacts. It is hoped that this study will be a motivator for other studies in other basins of the country.

We at the MoEnv hope that this and other studies of the JP will provide a practical guide for the harmonization of the implementation of climate change adaptation and issues within the conceptual system of the strategic planning of all concerned parties.

Eng. Ahmad Al-Qatarneh

Secretary General
Ministry of Environment

Acknowledgements

This study was part of a multi task project implemented by the MoEnv with support from UNDP. The project represents one component out of four with together form the UNCT joint programme titled "Adaptation to Climate Change to Sustain Jordan's MDG Achievements" implemented by the MWI, MoEnv, MOA, MOH, and MOPIC, in cooperation with UNDP, WHO-CEHA, UNESCO, and FAO.

This component (MoEnv-UNDP project) was coordinated by a national participatory process that lasted for three and a half years and involved tens of national experts and organizations resulted in the preparation of this and many other studies. The project was funded by the Spanish MDG-F, administered by UNDP, and implemented by the Ministry of Environment.

The project was coordinated by:

- Dr. Munjed Al-Sharif – Joint Programme Co-ordinator and Chief Technical Advisor
- Ms. Rana Saleh - JP assistant

The project management team was supported by the influential efforts of the various counterparts in the Ministry of Environment with special thanks going to Eng. Ahmad Qatarneh, the SG of the MoEnv and head of the MoEnv task force, Eng. Hussein Shahin, Director of Nature Directorate and Eng. Hussein Badareen, Director of Monitoring and Assessment Directorate, the project counterparts at the MoEnv and members of the task force. Appreciation is also extended to the other members of the task force Eng. Abdel Majeed Khaboor, Director of Zarqa Environment Directorate, and Mr. Batir Wardam, Head of the Zarqa river rehabilitation project and unit at the MoEnv.

The Ministry of Water and Irrigation has supported this study and participated in all its workshops and meetings. Their detailed review and feedback on the report were instrumental in upgrading it and strengthening its contents. Special thanks to Eng. Basem Telfah, The SG of the Ministry of Water and Irrigation, Eng. Maysoon Al Zoubi, the previous SG of the MWI, Eng. Mohammad Al Momani, the advisor of MWI SG, Eng. Ali Subah, the Assistant SG, Eng. Mohammad Al Atrash, head of Studies Directorate, and Eng. Rania Abdel khaliq, head of the Environment Directorate.

The project outcomes and documents were the result of the innovative work of many Jordanian experts joining together a distinguished team representing the Science Triangle for Research, Training, and mangament (STRTM) consulting firm. The technical contribution was provided by:

- Dr. Ali El Naqa, Team Leader (Hashemite University, HU).
- Dr. Mohammad Al Qinneh (HU)
- Dr. Nizar Hammori (HU)
- Dr. Salahuddin Jaber (HU)

The project implementation has been facilitated by the efforts of many staff in the Ministry of Environment with special acknowledgement to Eng. Mohammad Al Alem, Eng. Faraj Al Taleb, and Eng Indera Al Dahabi, from the Monitoring and Evaluation Directorate, and Eng. Sameer Al Kilani, the Projects Director. All regards and thanks are also extended to many professionals, practitioners and partners who have attended the various workshops of this project and impacted the progress of the project and the resulting studies with their valuable comments.

The Ministry of Environment would like to express thanks for all the experts participating in the project reports and action plan development, partners in the Ministry of Water and Irrigation, Ministry of Planning and International Cooperation, UNDP and all organizations that were influential and positive in their support of the project.

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1. Preface

According to Model Contract for Professional Consulting Services between UNDP and Science Triangle for Research, Training and Management No. (8/2010), thismanual document the whole process adopted in Objective 1 entitled "Develop needed adaptation measures for water quality and availability in the ZRB" in a detailed manner to be used for future capacity and building training sessions. This manual provide guidance for planners and decision makers with the necessary information about the methodology adopted in this task and the necessary steps that should be followed to implement such study on different location.

2. Introduction

Climate is changing, and this issue is no longer subject of discussion among scientists, however, the question is, when and where we are going to affected, what are the potential impacts in terms of magnitude, extent and severity. This will pose huge challenges to nations, organizations, enterprises, cities, communities and even individuals. Developing countries with limited water resources like Jordan are going to suffer most from the adverse consequences of climate change, and some highly vulnerable regions and people are already being affected.

Stopping climate change is another issue that is out of discussion, and most of the efforts focus on the adaption to climate change impacts. In order to make the necessary adaptation to the consequences of climate change, decision makers must be well informed. At the international level, knowledge of the consequences of humankind's behavior on our climatic system – presented, for example, in the latest IPCC assessment reports – is well-founded and adequate for policy makers. However, more specific information is needed for the implementation of concrete measures at the local level. It has been shown that the lack of such information is one of the severest bottlenecks to concrete action, in particular with regard to adaptation, but also for the implementation of integrated activities that would promote both mitigation and adaptation.

According to Assessments of Impacts and Adaptations to Climate Change (AIACC) final report which released in 2007, there are nine important lessons about adaptation to be learned, as well as, many more lessons that are specific to particular places and contexts. The general lessons, formulated as recommendations, are:

a) Adapt now

Climate changes threats is widening, and this seen in many case studies and sites. Taking the im-

mediate action to narrow the impacts can yield immediate benefits. The immediate actions will also serve as a useful and essential, first step in a longer-term process of adapting to a changing climate.

b) Create conditions to enable adaptation

According to this report, it was noticed that there are several obstacles that hinder adaptation in different sites, these include, competing priorities that place demands on scarce resources, poverty that limits capacity to adapt, lack of knowledge, weak institutions, degraded natural resources, inadequate infrastructure, insufficient financial resources, distorted incentives and poor governance. Therefore, enabling the adoption and facilitating its requirements is the first step in the adaptation process.

c) Integrate adaptation with development

Adaption to climate change should be integrated with any development plans. For effective integration, the engagement of responsible ministries for development, finance, economic sectors, land and water management, and provision of public health and other services and stockholders is required.

d) Increase awareness and knowledge

To ensure a successful adaption plan, there should be need for programs to help advance, communicate, interpret and apply knowledge for managing climate risks.

e) Strengthen institutions

Another key point in the successful adaptation planning is the presence of strongly resourced initiations. Local institutions, including modern organizations, informal associations, kinship networks and traditional institutions, serve functions in communities that help to limit, hedge and spread risks.

f) Protect natural resources

Natural resources and its sustainability are the main objective of any development plan. Knowing that such resources especially in developing countries are highly sensitive to climate change, it is becomes very important to consider the protection of natural resources in any adaptation plan.

g) Provide financial assistance

Lack of financial resources is commonly cited as a major obstacle to adaptation (AIACC, 2007). The constraint is particularly binding on the poor and the very poor, who typically are among the most vulnerable to climate change. Involve those at risk.

h) Involve those at risk.

To ensure the successful implementation of any adaption plan, the different stakeholders should be

involved in the process. This will increase the effectiveness of adaptation to climate change.

i) Use place-specific strategies

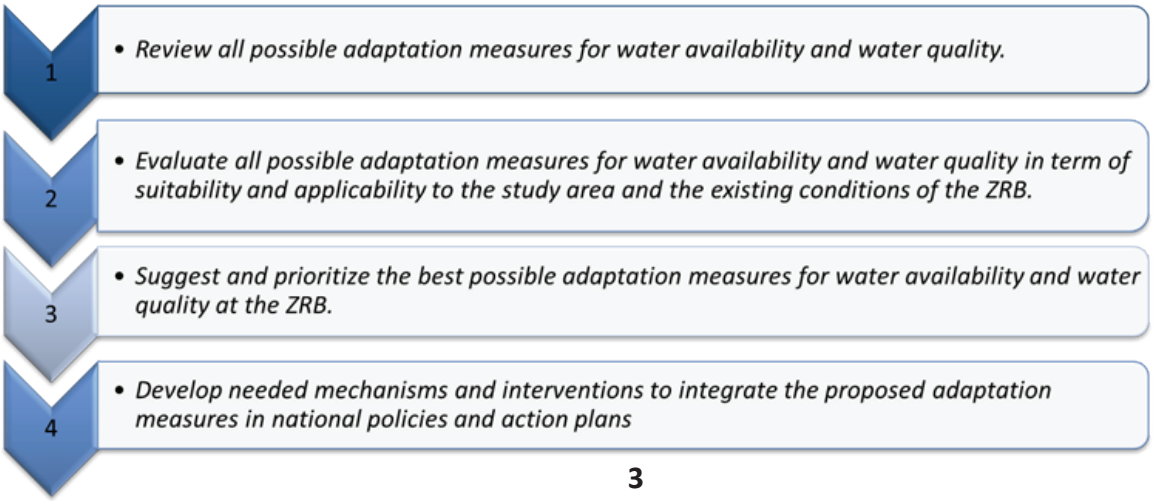
Adaptation is place-based and requires place-specific strategies (Leary et al, 2007). For example, peoples that facing a specific risk may barely on different strategies for managing the risks that reflect differences in the level of economic development of their surrounding community, strength of community institutions, locally available natural resources and differences in seasonal rain patterns (Chinvanno et al, 2008). General lessons can be applied in these different settings to help guide adaptive strategies, but details of the local context will determine the specific approaches and measures that will be most effective in each place (Leary et al, 2007).

3. Objectives

The main objective of this report is to document the whole process adopted in task of Objective 1 "Develop needed adaptation measures for water quality and availability in the ZRB" in a detailed manner to be used for future capacity and building training sessions. This document will be used in the future as a guide for identifying the best adaptation option for a site or a location.

4. Methodology

Objective One "Develop needed adaptation measures for water quality and availability in the ZRB" are going to be implemented through a set of the following action plans and activities:



In the next section, the mechanism that adopted to implement each of these action plans and activities are going to be discussed with more details.
It is important to mention that the whole process was started by conducting a meeting with stakeholders in 30 of May 2010. This meeting was aimed at launch the project, beside another important beneficiations like:

1. To have clear effective and useful opinions, comments, recommendations, and possible changes on the project work plans, actions, tasks, and methodologies adopted to fulfill the necessary objectives.
2. Fostering stakeholder participation in research projects to bridge the gap between scientists, policy-makers and all other relevant parties.
3. Engaging stakeholders more could streamline the flow and sharing of information, and avoid duplication of work and undue delays in taking decisions.
4. Improve understanding of local knowledge and practices and public awareness, which are essential for successfully implementing adaptation measures, avoiding mal-adaptation and unsustainable solutions.
   In fact, stakeholder's opinion is of great value through the implementation of different stages of this project. And in each step, their feedback is critical, since they are the object and target of climate change adaption process.

5. Review all possible adaptation measures for water availability and water quality.

The revision process will be achieved through detailed investigation for all possible adaptation measures outlined in literature in accordance to different international sources like:

a) IPCC - Intergovernmental Panel on Climate Change (www.ipcc.ch),

b) UNFCCC - United Nations Framework Convention on Climate Change (www.unfccc.int).

These are the most important sources in the revision process; however, other sources might be of great value like:

c) UNDP – United Nation Development Program – Adaption to climate change (http://www.undp.org/climatechange/adapt/),

d) UNDP CAP-NET / IWRM and Adaptation to Climate Change (http://www.cap-net.org/),

e) EPS – Environmental Protection Agency Climate Change Home (http://www.epa.gov/climatechange/index.html),

f) CCIAD - Climate Change Impacts and Adaptation, Natural Resources Canada (http://adaptation.nrcan.gc.ca/index_e.php),
g) AIACC - Assessments of Impacts and Adaptation to Climate Change (http://start.org/programs/aiacc),
h) LCA – Linking Climate Adaption (http://www.eldis.org/go/topics/dossiers/climate-change-adaptation).

The revision process will focus on the following issues:

1. Review all possible adaptation measures for water availability for conventional and nonconventional water as wastewater reuse, water desalination, weather modification, brackish water, industrial wastewater.
2. Review all possible adaptation measures for water demand management, residential water supply, surface water development, groundwater recharge.
3. Review all possible adaptation measures for water quality in terms of pollution, protection and management.
4. Review all possible adaptation measures for water monitoring system, measures to improve system efficiency, watershed management, urban water use, flood control, research programs, institutional reform, and irrigation water.
5. Review all possible adaptation measures related to socio-economic issues.

Based on this revision, all possible adaptation measures for water availability and water quality are listed in Appendix A.

6. Evaluate all possible adaptation measures for water availability and water quality in term of suitability and applicability to the study area and the existing conditions of the ZRB, and Suggest and prioritize the best possible adaptation measures for water availability and water quality at the ZRB.

These two tasks are highly interrelated. The outputs from the previous task are going to be analyzed and evaluated to check its suitability and applicability for the existing conditions of ZRB.
In order to facilitate the evaluation process, the following method was adopted:

1. Amulti criteria score based method was used to derive into the correct evaluation point. A set of criteria was selected based on different sources like IPCC forth assessment guideline report. These criterions appear in table (1).
2. The score represent the sum of the weights of each sub-criteria used in the evaluation multiplied by the ratio.
3. Weights were assigned by the stakeholders according to their importance in the evaluation, and sums up to 100% (See table 1).
4. The ratio is the stakeholder judgment for each proposed adaptation under each sub-criteria (criterion) having a range from 1 to 5, where 1 represent the lowest level and 5 represent the high ratio level.

According to the evaluation of the opportunities, barriers, and suitability of each suggested adaptation to climate change risks will be ranked according to combination of elements from various options (decision support tool).
It is suggested that, the most feasible immediate actions should be set the first especially that deals with management of existed infrastructures and the institutional frameworks that deals with those entities.

The “best” or “preferred” option involves the costs, benefits, and impacts of alternative strategies comparison.

Setting priorities requires choosing criteria to weigh different concerns. These criteria can also act as indicators of the success or failure to realize the objectives, and can be used by a monitoring-evaluation programme for the adaptation strategies, policies and measures.
An excel sheet was developed to facilitate this process, and it was distributed among different stakeholders to have their opinion and feedback, the final scores was calculated based on averaging the scores obtained from the responded stakeholders (Appendix B). The prioritized adaptation measures based on this analysis appear in Appendix C.

Table 1:Criteria used for evaluating the suggested adaptation measures.

Criteria	Sub-criteria	Description	Weight	Sub-weight
Sustainability	Mitigation (adaptation) benefits	Changes in the level of greenhouse gas emissions created by the adaptation measure	25	10
	Ecosystem Impact	The degree of environmental impacts on biodiversity		7
	Equity	Number of people benefiting from the adaptation - if possible disaggregated by gender, age, class		8
Effectiveness	Robustness (ability to adopt under different scenarios)	Elaborate how effective this measure could be for a diverse range of plausible future scenarios	20	5
	Reliability	Identify if this measure is untested or the effectiveness of this measure is proven		5
	Cost Effectiveness (Low-regret)	Identify if this measure will bring high relative benefits to the costs		10
Risk and Urgency	Urgency	Identify the time frame of impact occurrence from recent past, present until short- and long-term futures	15	5
	Degree of risk (potential extent of future risks)	Identify potential extent of future risks from minor and reversible until irreversible		5
	Uncertentity or Precautionary	Estimate how well the risks are understood		5
Opportunity	Ancillary benefits	Identify how this measure will contribute to other community goals	10	3
	No-regret option	Indentify if this measure has benefits regardless of actual climate change impacts		3
	Window of opportunity	Identify if there is currently a window of opportunity to implement this measure		4
Opportunity	Initial cost	Identify the approximate cost of implementation; you could compare these costs with cost of inaction over time	30	5
	Operating and maintenance cost	Identify the cost of operation and maintenance over time, compared to other budget expenditures		5
	Public acceptability	Elaborate on public support or opposition to this measure		5
	Funding sources	Identify availability and sources of potential funding		5
	Capacity (information, technical, staff, resources)	Estimate if current capacity is sufficient and, if not, what are lacking capacity gaps		5
	Institutional	Identify if implementation is within local control or it requires coordination with, or action by, other jurisdictions		5

Final Score	Sum of All Scores Multiplied by its Weight (Total Scores 500)	→	Divide the results by 5 to have the range out of 100

Another important issue that should be considered when evaluation the different potential adaptation measures is the assessment of barriers and constrains that may threat the implementation of any of the suggested adaptation measures. Based on a general classification of adaptation barriers, potential barriers to implementation of adaptation measures have been analyzed and evaluated according to their degree of severity.

A quantitative ratio-level approach was adopted in this project to assess the magnitude and likelihood of risks and opportunities using the level of effectiveness and severity status. Three levels were adopted; national (N), local (L), and project (P). While the three severity magnitudes were assigned; low (L), medium (M), and high (H). Again, stockholders opinion was also considered at this this step where an Excel sheet was created and distributed among different stockholders to facilitate the data collection process. The obtained results from this assessment can be found in Appendix D.

According to the results of the categorization and evaluation, most of the existed barriers to climate change adaptation measures at ZRB fall within the financial and technical aspects followed by social and institutional constrain (Appendix D).

7. Develop needed mechanisms and interventions to integrate the proposed adaptation measures in national policies and action plans.

Governments all over the world use a variety of policy instruments and tools aimed at integrating the proposed adaptation measures in national policies and action plans. To develop the needed mechanisms and interventions to integrate the proposed adaptation measures in national policies and action plans, the following should be considered:

- First governments determine the overall goals through the issuance of environmental standards, and then they choose the means to achieve those goals through either command-and-control and/or market approaches (including environmental subsidies, taxes, deposit/refund system, and/or permit trading systems).
- The governments legislates those goals and means and finally monitor and enforce those goals and means.
- All international environmental standards, policy tools and instruments related to climate change will be reviewed. The most suitable combination of these instruments and tools will be suggested for adoption in ZRB

In Jordan as in other countries, mismanagement, and rapid population and economic growth, raise

water shortage constraints that are generally greater than those forecasted to result from climate change. Yet, climate change poses a conceptual challenge to water management by introducing uncertainty in future hydrological conditions.

According to Cap-Net Training Manual and Operational Guide on Integrated Water Resources Management Plans (Cap-Net, 2005) presents the process in seven sequential steps. When viewing the IWRM planning process as instrumental for adaptation to changing climatic conditions, the following may be considered:

- In the 'Initiation' step, climate change impacts need to be integrated in the planning process. In advocacy towards policy makers, the argument can be brought up that this will be instrumental for decision makers to advance demand management strategies, which otherwise might be politically difficult to implement.
- During the 'Vision/policy' phase, climate change adaptation is an additional element, not a replacement of IWRM goals. The overall aims of IWRM will remain the same.
- In the 'Situation analysis' step, the use of climate information and impact analysis needs be incorporated. Further, the adaptation/mitigation theme can be brought out to suggest that the IWRM process should reduce the risk of adaptation options negatively impacting on the mitigation targets, and vice versa.
- In the 'Strategy choice' phase, the anticipatory or 'precautionary' approach can be introduced as the basis for strategies for IWRM.
- Consider the roles of local authorities and river basin organizations (RBOs) in adaptation strategies when drafting an IWRM plan.
- Legal frameworks, economics and health, and other variable conditional elements that have been analyzed from the corner stone for implementation of IWRM and are decisive in how it contributes to climate change adaptation.
- During evaluation, results must be measured against indicators, taking into consideration the adaptation measures proposed in the plan.

Throughout the process, stakeholder involvement is essential so that the results of the impacts assessment and strategic choice are owned by the implementing agencies. The range of solutions and strategies has been broadened over time by improvements in technologies. What has changed is our understanding and implementation of the integrated ensemble of water management measures that conform to modern principles and policies. A catchment is composed of many users, who reside

Appendix A

List of potential adaptation measures for water availability and water quality

	Prevention measures	Measures to improve resilience	Preparation measures	Response measures	Recovery measures
Demand and supply management	Reduction of losses from the supply networks	Transfer of water among different basins in Jordan	Water harvesting		
	Introduction of water saving technologies	Adaptation of different cropping patterns	Reuse of treated wastewater and industrial wastewater resources		
		implementing soil and water programs	Desalination		
			Weather modification (cloud seeding)		
			Public awareness campaigns on water consumption		
Surface water Development	Modernizing and upgrading the storage capacity of existed water reservoirs	Protecting surface water supplies from point and non-point pollution sources	Constructing new surface dams and ponds		
	Minimizing losses by surface evaporation from existed water bodies	Conversion of open canal systems to a pressurized pipe system	Construction of desert dams		
	Minimizing losses by subsurface seepage from existed water bodies	Management of flash floods	Constructing subsurface storage and dams		
	Reduction of deposition of sediments beyond the construction and mining areas	Protecting dams and stream flow	Increase the monitoring systems		
Groundwater Pro	Introducing metering	Providing sources for recharge the aquifer	Protection of groundwater from contamination		
	Use of piping for transfer of treated water from WWTP	Importing water from other basins	Remediation of all polluted groundwater sources		
		Public and stakeholder participation in groundwater management			
		Substitute by treated wastewater for industrial uses			
		Developing and utilizing deep groundwater aquifers			
		Desalination of brackish groundwater			
		Increase of monitoring systems			

		Prevention measures	Measures to improve resilience	Preparation measures	Response measures	Recovery measures
Unconventional Water Management	Wastewater	Recharge to groundwater	Efficient utilization of treated wastewater	Improvement of existed wastewater treatment plants	Transfer of water among different basins in Jordan	Transfer of water among different basins in Jordan
				Better management of septic tank water		
				Temporary wastewater storage facilities		
				Raising awareness and Training programs		
				Constructing small power station		
				Expansion of the use of decentralized WWTPs		
				Effective water quality monitoring and compliance		
				Emergency programs		
	Industrial Wastewater	Reuse of treated wastewater in industry	Use of brackish industrial water for specific on-site plant programs	Implementation of on-site industrial WWTP		
		Recycle of treated industrial water		Developing of a new Industrial Waste Water Treatment Plants (IWWTP)		
		Reuse of industrial wastewater locally		Developing and enforcing laws and regulations regarding industrial wastewater		
				Implementation of an industrial wastewater discharge fee system		
				Implementation of an industrial waste minimization program		
				Implementation of a central toxic and hazardous waste handling and treatment facility		
				Emergency handling and containment facilities for industrial waste dischargers		
	Brackish water			Implementing new desalinization projects		
	Grey Water	Introduce the use of greywater for gardening		Construction of on-site water treatments in large enterprises		
	Virtual Water			Importing water intensive agricultural products		

	Prevention measures	Measures to improve resilience	Preparation measures	Response measures	Recovery measures
Irrigation management	Use of drought-tolerant and salt-resistant crops	Conservation and restoration of ecosystems	Upgrading irrigation infrastructure		
	Use of water-efficient technology		Engaging in water trade, in either the temporary or permanent market		
	Alter the mix and level of production		Construction of small on-farm reservoirs		
	Reduce production		Implement water harvesting techniques at farm level		
	Improve farm management practices		Raising awareness		
	Use of greywater		Development of drought management plan		
	Desalination of brackish water at farm level				
Social Development		Use existing systems and links to general and emergency response systems	Building resilient housing	Restriction of urban development in flood risk zones	
		Public education, awareness raising, and public participation	modifying transport infrastructure		
		Strengthen the mechanism for early warning and action	Migration of people away from high-risk areas		
			Strengthen and use a capacity for long-term preparation and planning, especially to identify, address and remedy the underlying social and environmental determinants that increase vulnerability		
			Developing water safety plans		
			Establish Climate Information System (CIS)		

Appendix B

Evaluation results of suggested adaptation measures according to stakeholder participation.

Implementer	TEAM		MoENV		MWI		Farmers		MoAgr		Muncipality		Overall	
Criteria	Score		Score		Score		Score		Score		Score		Score	
Sub-criteria														
Weight	Total		Total		Total		Total		Total		Total		Total	
Sub-weight	500	%	500	%	500	%	500	%	500	%	500	%	500	%
1. Demand and Supply Management														
Implementation of artificial groundwater recharge to sustain water demands	451	90.2	326	65.2	334	66.8	370	74	420	84	383	77	381	76
Water harvesting	454	90.8	379	75.8	343	68.6	392	78	432	86	400	80	400	80
Reuse of treated wastewater and industrial wastewater resources	409	81.8	354	70.8	336	67.2	366	73	393	79	372	74	372	74
Desalination	414	82.8	305	61	385	77	368	74	408	82	370	74	375	75
Weather modification (cloud seeding)	256	51.2	211	42.2	382	76.4	283	57	346	69	281	56	293	59
Transfer of water among different basins	380	76	164	32.8	100	20	215	43	318	64	239	48	236	47
Reduction of losses from the supply networks	390	78	412	82.4	439	87.8	414	83	431	86	420	84	418	84
Introduction of water saving technologies	447	89.4	415	83	304	60.8	389	78	442	88	390	78	398	80
Public awareness campaigns on water consumption	458	91.6	418	83.6	390	78	422	84	446	89	426	85	427	85
Adaptation of different cropping patterns	467	93.4	390	78	400	80	419	84	449	90	426	85	425	85
Implementing soil and water programs	467	93.4	399	79.8	384	76.8	417	83	448	90	424	85	423	85
2. Surface Water Development														
Modernizing and upgrading the storage capacity of existed water reservoirs,	384	76.8	377	75.4	399	79.8	387	77	395	79	386	77	388	78
Constructing new surface dams	412	82.4	367	73.4	400	80	393	79	409	82	394	79	396	79
Construction of desert dams	447	89.4	350	70	400	80	399	80	433	87	404	81	405	81
Constructing subsurface storage and dams	333	66.6	309	61.8	300	60	314	63	326	65	317	63	316	63
Minimizing losses by surface evaporation from existed water bodies	381	76.2	352	70.4	310	62	348	70	373	75	350	70	352	70
Minimizing losses by subsurface seepage from existed water bodies	377	75.4	334	66.8	300	60	337	67	364	73	341	68	342	68
Protecting surface water supplies from point and non-point pollution sources	472	94.4	389	77.8	372	74.4	411	82	449	90	420	84	419	84
Conversion of open canal systems to a pressurized pipe system	373	74.6	308	61.6	382	76.4	354	71	383	77	352	70	359	72

Reduction of deposition of sediments beyond the construction and mining areas	346	69.2	284	56.8	200	40	277	55	328	66	282	56	286	57
Increase the monitoring systems	388	77.6	369	73.8	490	98	416	83	462	92	416	83	423	85
Management of flash floods	381	76.2	346	69.2	400	80	376	75	395	79	374	75	379	76
Protecting dams and stream flow	388	77.6	359	71.8	395	79	381	76	394	79	380	76	383	77
3. Groundwater Protection														
Introducing metering	399	79.8	405	81	400	80	401	80	404	81	402	80	402	80
Providing sources for recharge the aquifer	385	77	372	74.4	400	80	386	77	396	79	385	77	387	77
Importing water from other basins	363	72.6	193	38.6	466	93.2	341	68	438	88	331	66	355	71
Protection of groundwater from contamination	462	92.4	374	74.8	400	80	412	82	444	89	419	84	418	84
Public and stakeholder participation in ground-water management	430	86	435	87	285	57	383	77	444	89	380	76	393	79
Substitute by treated wastewater for industrial uses	359	71.8	364	72.8	300	60	341	68	366	73	340	68	345	69
Developing and utilizing deep groundwater aquifers	309	61.8	258	51.6	385	77	317	63	363	73	314	63	324	65
Desalination of brackish groundwater	421	84.2	312	62.4	300	60	344	69	391	78	356	71	354	71
Remediation of all polluted groundwater sources	385	77	357	71.4	300	60	347	69	378	76	349	70	353	71
Use of piping for transfer of treated water from WWTP	338	67.6	302	60.4	200	40	280	56	331	66	282	56	289	58
Increase of monitoring systems	405	81	384	76.8	400	80	396	79	404	81	397	79	398	80
4. Unconventional Water Management 4.1 Domestic Wastewater														
Improvement of existed wastewater treatment plants	419	83.8	394	78.8	390	78	401	80	412	82	404	81	403	81
Better management of septic tank water	413	82.6	324	64.8	300	60	346	69	388	78	355	71	354	71
Temporary wastewater storage facilities	331	66.2	348	69.6			340	68	346	69	343	69	342	68
Efficient utilization of treated wastewater	445	89	387	77.4	385	77	406	81	430	86	412	82	411	82
Raising awareness and Training programs	476	95.2	425	85	300	60	400	80	464	93	404	81	412	82
Constructing small power station	354	70.8	295	59	300	60	316	63	339	68	322	64	321	64
Recharge to groundwater	334	66.8	337	67.4	345	69	339	68	343	69	340	68	339	68
Expansion of the use of decentralized WWTPs	322	64.4	343	68.6	400	80	355	71	384	77	361	72	361	72
Effective water quality monitoring and compli-ance	402	80.4	397	79.4	450	90	416	83	437	87	417	83	420	84
Emergency programs	394	78.8	359	71.8	300	60	351	70	385	77	354	71	357	71

4.2 Industrial Wastewater														
Implementation of on-site industrial WWTP	401	80.2	347	69.4	360	72	369	74	389	78	374	75	373	75
Reuse of treated wastewater in industry as a substitute for groundwater	351	70.2	332	66.4	275	55	319	64	347	69	320	64	324	65
Recycle of treated industrial water	333	66.6	348	69.6	200	40	294	59	351	70	290	58	303	61
Reuse of industrial wastewater locally	382	76.4	335	67	200	40	306	61	372	74	308	62	317	63
Use of brackish industrial water for specific on-site plant programs	392	78.4	346	69.2	300	60	346	69	379	76	351	70	352	70
Developing and enforcing laws and regulations regarding industrial wastewater	399	79.8	393	78.6	300	60	364	73	403	81	363	73	370	74
Developing of a new Industrial Waste Water Treatment Plants (IWWTP)	401	80.2	332	66.4	300	60	344	69	381	76	352	70	352	70
Implementation of an industrial wastewater discharge fee system	363	72.6	325	65	210	42	299	60	356	71	301	60	309	62
Implementation of an industrial waste minimization program	303	60.6	323	64.6	309	61.8	312	62	319	64	313	63	313	63
Implementation of a central toxic and hazardous waste handling and treatment facility	300	60	295	59	300	60	298	60	300	60	298	60	299	60
Emergency handling and containment facilities for industrial waste dischargers	369	73.8	332	66.4	205	41	302	60	363	73	304	61	312	62
4.3. Brackish water														
Implementing new desalinization projects,	426	85.2	326	65.2	205	41	319	64	397	79	328	66	334	67
4.4. Greywater														
Introduce the use of greywater for gardening,	386	77.2	358	71.6	205	41	316	63	385	77	317	63	328	66
Construction of on-site water treatments in large enterprises,	400	80	328	65.6	205	41	311	62	381	76	317	63	324	65
4.5. Virtual Water														
Importing water intensive agricultural products	305	61	385	77	205	41	298	60	362	72	292	58	308	62
5. Irrigation Management														
Use of drought-tolerant and salt-resistant crops	433	86.6	422	84.4	300	60	385	77	437	87	384	77	394	79
Upgrading irrigation infrastructure	428	85.6	433	86.6	300	60	387	77	440	88	384	77	395	79
Use of water-efficient technology	459	91.8	420	84	300	60	393	79	452	90	395	79	403	81
Conservation and restoration of ecosystems	415	83	431	86.2	300	60	382	76	433	87	379	76	390	78
Engaging in water trade, in either the temporary or permanent market.	317	63.4	337	67.4	385	77	346	69	371	74	352	70	351	70
Alter the mix and level of production	418	83.6	315	63	400	80	378	76	417	83	378	76	384	77
Reduce production	338	67.6	254	50.8	300	60	297	59	327	65	301	60	303	61

Construction of small on-farm reserviors	400	80	348	69.6	316	63.2	355	71	385	77	360	72	361	72
Implement water harvesting techniques at farm level	458	91.6	346	69.2	365	73	390	78	432	86	400	80	398	80
Improve farm management practices	443	88.6	376	75.2	250	50	356	71	426	85	362	72	369	74
Use of greywater	385	77	348	69.6			367	73	382	76	368	74	370	74
Desalination of brackish water at farm level	414	82.8	327	65.4			371	74	406	81	374	75	378	76
Raising awareness	408	81.6	417	83.4			413	83	416	83	414	83	414	83
Development of drought management plan	450	90	397	79.4			424	85	445	89	425	85	428	86
6. Socio														
Use existing systems and links to general and emergency response systems	404	80.8	360	72			382	76	400	80	384	77	386	77
Building resilient housing	370	74	353	70.6			362	72	368	74	362	72	363	73
Restriction of urban development in flood risk zones	395	79	313	62.6			354	71	387	77	357	71	361	72
Public education, awareness raising, and public participation	409	81.8	424	84.8			417	83	423	85	419	84	418	84
Modifying transport infrastructure	376	75.2	308	61.6			342	68	370	74	345	69	348	70
Strengthen the mechanism for early warning and action	394	78.8	330	66			362	72	388	78	364	73	368	74
Migration of people away from high-risk areas	371	74.2	277	55.4			324	65	362	72	327	65	332	66
Strengthen and use a capacity for long-term preparation and planning, especially to identify, address and remedy the underlying social and environmental determinants that increase vulnerability	394	78.8	380	76			387	77	393	79	388	78	388	78
Developing water safety plans	384	76.8	362	72.4			373	75	382	76	374	75	375	75
Establish Climate Information System (CIS)	370	74	335	67			353	71	367	73	354	71	356	71

Appendix C

Prioritized adaptation measures based on multi criteria analysis.

Colors Legend
1. Demand and Supply Management
2. Surface Water Development
3. Groundwater Protection
4. Unconventional Water Management
5. Irrigation Management
6. Socio

Suggested Mitigation Measure	Score
Development of drought management plan	85.6
Public awareness campaigns on water consumption	85.3
Adaptation of different cropping patterns	85.0
Increase the monitoring systems	84.7
Implementing soil and water programs	84.6
Effective water quality monitoring and compliance	84.0
Protecting surface water supplies from point and non-point pollution sources	83.8
Protection of groundwater from contamination	83.7
Public education, awareness raising, and public participation	83.7
Reduction of losses from the supply networks	83.5
Raising awareness	82.7
Raising awareness and Training programs	82.3
Efficient utilization of treated wastewater	82.1
Construction of desert dams	81.1
Improvement of existed wastewater treatment plants	80.7
Use of water-efficient technology	80.6
Introducing metering	80.4

Water harvesting	80.0
Implement water harvesting techniques at farm level	79.7
Introduction of water saving technologies	79.5
Increase of monitoring systems	79.5
Constructing new surface dams	79.2
Upgrading irrigation infrastructure	79.1
Use of drought-tolerant and salt-resistant crops	78.7
Public and stakeholder participation in groundwater management	78.6
Conservation and restoration of ecosystems	78.0
Strengthen and use a capacity for long-term preparation and planning	77.6
Modernizing and upgrading the storage capacity of existed water reservoirs	77.6
Providing sources for recharge the aquifer	77.4
Use existing systems and links to general and emergency response systems	77.2
Alter the mix and level of production	76.8
Protecting dams and stream flow	76.5
Implementation of artificial groundwater recharge to sustain water demands	76.1
Management of flash floods	75.7
Desalination of brackish water at farm level	75.6
Developing water safety plans	75.0
Desalination	75.0
Implementation of on-site industrial WWTP	74.7
Reuse of treated wastewater and industrial wastewater resources	74.4
Developing and enforcing laws and regulations regarding industrial wastewater	74.1
Use of greywater	74.0
Improve farm management practices	73.8
Strengthen the mechanism for early warning and action	73.5
Building resilient housing	72.6
Restriction of urban development in flood risk zones	72.3
Expansion of the use of decentralized WWTPs	72.2
Construction of small on-farm reservoirs	72.1
Conversion of open canal systems to a pressurized pipe system	71.8

Emergency programs	71.4
Establish Climate Information System (CIS)	71.1
Importing water from other basins	71.1
Better management of septic tank water	70.9
Desalination of brackish groundwater	70.8
Remediation of all polluted groundwater sources	70.6
Minimizing losses by surface evaporation from existed water bodies	70.5
Use of brackish industrial water for specific on-site plant programs	70.4
Developing of a new Industrial Waste Water Treatment Plants (IWWTP)	70.3
Engaging in water trade, in either the temporary or permanent market	70.3
Modifying transport infrastructure	69.6
Substitute by treated wastewater for industrial uses	69.0
Minimizing losses by subsurface seepage from existed water bodies	68.5
Temporary wastewater storage facilities	68.3
Recharge to groundwater	67.9
Implementing new desalinization projects,	66.7
Migration of people away from high-risk areas	66.5
Introduce the use of greywater for gardening,	65.6
Developing and utilizing deep groundwater aquifers	64.9
Reuse of treated wastewater in industry as a substitute for groundwater	64.8
Construction of on-site water treatments in large enterprises,	64.7
Constructing small power station	64.2
Reuse of industrial wastewater locally	63.4
Constructing subsurface storage and dams	63.3
Implementation of an industrial waste minimization program	62.6
Emergency handling and containment facilities for industrial waste dischargers	62.5
Implementation of an industrial wastewater discharge fee system	61.8
Importing water intensive agricultural products	61.6
Reduce production	60.6
Recycle of treated industrial water	60.5
Implementation of a central toxic and hazardous waste handling and treatment facility	59.7

Weather modification (cloud seeding)	58.6
Use of piping for transfer of treated water from WWTP	57.8
Reduction of deposition of sediments beyond the construction and mining areas	57.2
Transfer of water among different basins	47.2

Appendix D

Analyzed set of possible barriers and opportunities.

Barrier	Institutional									Political									Financial									Social									Technical									Environment								
Level	N			L			P			N			L			P			N			L			P			N			L			P			N			L			P			N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Week of pertinent laws or regulations		x									x										x			x			x																										
Insufficient and/or ineffective law enforcement		x																			x			x			x																										
Lack of Effective Regulatory Agencies	x																				x			x			x																										
The incongruence between long term processes of climate change and the short time horizon of politicians and policies.			x																		x			x			x																										
Lack of cooperation between sectoral authorities and integration in policy plans			x																		x			x			x		x			x			x																
Top-down interventions without local anchoring		x																			x			x			x		x			x			x			x														
Little or no participation besides high-level government officials			x			x															x			x			x																										
Adaptation initiatives are dependent upon external, donor funded expert intervention		x																			x			x			x																										

Barrier	Institutional									Political									Financial									Social									Technical									Environment								
Level	N			L			P			N			L			P			N			L			P			N			L			P			N			L			P			N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Absence of invisibility of model behavior by opinion leaders			x			x															x			x			x																									
Failure of managers to provide needed social support			x			x			x												x			x			x																									
Organization form obscuring negative externalities								x													x			x			x																									
Little research work on the practical application of policy measures for adapting to climate change, National scientific community has not had an active role in addressing vulnerability and adaptation issues		x			x																x			x			x																									
Financial support is limited (inadequate financial capacity to develop or modify existing models and methodologies, lack of financial sources to implement the adaptation measures)																					x			x			x																									
Lack of coordination on cross-sectoral issues.																					x			x			x										x			x			x								

Barrier	Institutional									Political										Financial										Social										Technical										Environment									
Level	N			L			P			N			L			P				N			L			P				N			L			P				N			L			P				N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H		L	M	H	L	M	H	L	M	H		L	M	H	L	M	H	L	M	H		L	M	H	L	M	H	L	M	H		L	M	H	L	M	H	L	M	H
Weak co-ordination and cooperation among national and technical cooperation programs/ projects			x			x														x			x			x															x			x			x											
Lack of policies to facilitate the implementation of national adaptation plans			x			x														x			x			x																															
Little to no climate expertise within many management units at the regional and local level; disconnect between science and management that impedes access to information																				x			x			x															x															
Long time and high transaction costs for small projects																				x			x			x															x															
The ability of ecosystems to adapt to climate change is severely limited by the effects of urbanization, barriers to migration paths, and fragmentation of ecosystems																				x			x			x																					x			x					
Lack of trust																				x			x			x			x											x															
Corruption		x			x			x												x			x			x			x			x			x																			
Adaptive capacity is uneven across and within societies.																				x			x			x			x				x			x																	

Barrier	Institutional									Political									Financial									Social									Technical									Environment								
Level	N			L			P			N			L			P			N			L			P			N			L			P			N			L			P			N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	P	M	H	L	M	H	L	M	H	P	M	H	L	M	H	L	M	H	P	M	H	L	M	H	L	M	H	P	M	H
Lack of cultural acceptance of change																					x			x			x						x			x																	
Poverty and compounding problems of poor/worsening local conditions																					x			x			x			x			x			x																	
Lack of community resources where high proportion of people rely on ecosystems for their livelihoods,																					x			x			x			x			x			x								x			x					x
Inability to feel responsibility for water sustainability																					x			x			x	x			x			x																	
Distorted or incomplete pricing policies		x																			x			x			x																											
Absence or inconsistency of financial incentives (rewards and punishments)			x																		x			x			x																											
Low financial resource base to cover the capital and running costs of most of the strategies.																					x			x			x																											
Low level of payment for services in certain areas or sectors.		x																			x			x			x																											
The quality and breadth of estimates of costs and benefits used in impact and adaptation assessments are weak			x			x			x												x			x			x																											

Barrier	Institutional									Political									Financial									Social									Technical									Environment								
Level	N			L			P			N			L			P			N			L			P			N			L			P			N			L			P			N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Adequate financial and human public health resources, including training,			x																		x			x						x			x			x																	
Lack of finance instruments to cover adaptation costs			x																		x			x																													
Low investment in environmental friendly technologies																					x			x																													
Unstable Macroeconomic Conditions																					x			x																													
The lack of sufficient and spatially detailed socioeconomic information in order to understand vulnerability at the sub national level.																					x			x			x			x									x			x									x		
Tacit and explicit knowledge on the impacts and vulnerabilities to projected climate changes are weak			x																		x			x			x			x																						
Lack of Data																					x			x															x			x									x		
Uncertainties in regional, local climate change scenarios, Socioeconomic scenarios																					x			x															x			x									x		
Weak national human andinstitutional capacity			x																		x			x															x													
Public awareness			x			x			x												x			x			x			x									x			x									x		

Barrier	Institutional									Political									Financial									Social									Technical									Environment								
Level	N			L			P			N			L			P			N			L			P			N			L			P			N			L			P			N			L			P		
Severity	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Data Reliability																					x			x			x											x			x			x										
Stakeholders /public awarness and participation			x			x			x												x			x			x											x			x			x										
Uncertainty about effectiveness and appropriateness of adaptation options																					x			x			x										x			x			x										
Inadquate or lack of technology transfer and technical capability																					x			x			x											x			x			x										
Lack of credibility about setting project baselines, and monitoring of carbon stocks pose difficult challenges.																					x			x			x																											
Farm-level Adoption Constraints																					x			x			x			x			x					x			x			x										
Lack of national standars for non- conventional water resources			x																		x			x			x																											
Political boundaries do not necessarily align with ecological processes												x			x						x			x			x																											
Seasonal management activities may be affected by changes in timing and duration of seasons																					x			x			x													x														

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