The National Framework
for Decentralized Wastewater Management in Jordan

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Decentralized Wastewater Management in Jordan
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NICE
National Implementation Committee for Effective Decentralized Wastewater Management

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Abbreviations

ACWUA	Arabic Countries Water Utilities Association
ALLOWS	Assessment of Local Wastewater Solutions
BGR	Federal Institute for Geosciences and Natural Resources (Germany)
BMBF	Federal Ministry of Education and Research (Germany)
BMZ	Federal Ministry for Economic Cooperation and Development (Germany)
BOD_5	Biological Oxygen Demand, 5 days
CD	Capacity Development
COD	Chemical Oxygen Demand
CWWT	Centralized Wastewater Treatment
DBO	Design – Build - Operate
DOS	Department of Statistics
DWWM	Decentralized Wastewater Management
DWWT	Decentralized Wastewater Treatment
DWWT	Decentralized Wastewater Treatment
DWWT&R	Decentralized Wastewater Treatment and Reuse
GAM	Greater Amman Municipality
GIZ	Gesellschaft für Internationale Zusammenarbeit
GoJ	Government of Jordan
CLUES	Community-Led Urban Environmental Sanitation Planning
HFCW	Horizontal Flow Constructed Wetland
HUDC	Housing and Urban Development Corporation
IUCN	International Union International Union for Conservation of Nature
JOD	Jordanian Dinar
JS	Jordanian Standard
JSMO	Jordanian Standards and Metrology Organization
JVA	Jordan Valley Authority
KfW	Kreditanstalt für Wiederaufbau
lpcd	Liters Per Capita per Day
MBR	Membrane Bioreactor
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MoH	Ministry of Health
MoM	Ministry of Municipal Affairs
MST	Modified Septic Tank
MWI	Ministry of Water and Irrigation
NGO	Non-Governmental Organization
NICE	National Implementation Committee for Effective Decentralized Wastewater Management in Jordan
NWMP	National Water Master Plan
O&M	Operation and Maintenance
PE	Person (Population) Equivalent
PMU	Performance Management Unit
PP	Participatory Planning

PSP	Private-Sector Participation
RVFCW	Recirculating Vertical Flow Constructed Wetland
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goal
SMART	Sustainable Management of Available Water Resources with Innovative Technologies
SMART Move	Management of Highly Variable Water Resources in semi-arid Regions
TPV	Total Project Value
TSS	Total Suspended Solids
TCC	Total Capital Costs
TIC	Total Indirect Cost
TN	Total Nitrogen
SS	Suspended Solids
UASB	Up Flow Anaerobic Sludge Blanket
UFZ	Helmholtz Centre for Environmental Research UFZ
UNHCR	United Nations High Commissioner for Refugees
VFCW	Vertical Flow Constructed Wetland
WAJ	Water Authority of Jordan
WHO	World Health Organization
WSP	Wastewater Stabilization Pond
WW	Wastewater
WWM	Wastewater Management
WWTP	Wastewater Treatment Plant

Executive Summary

Serving smaller communities in rural and suburban areas in Jordan with reliable wastewater management systems is essential to address serious concerns of stakeholders and the public over water scarcity, public health, and water resources protection. The potential for reuse of treated wastewater is traditionally viewed as a reliable alternative to alleviate pressure on freshwater resources in Jordan. Considering several social, technical and economic factors, there is a strongest argument in favor of decentralized wastewater management approach at rural and suburban areas in Jordan. But, while decentralized wastewater management in Jordan is progressing, further steps are required to effectively develop the sector and to adopt this approach in a sustainable manner.

With funding from the German Ministry of Education and Research - BMBF, both the Helmholtz Centre for Environmental Research - UFZ and the Jordanian Ministry of Water and Irrigation - MWI joint efforts to establish a collaboration project with the aim to develop a framework for the implementation of decentralized wastewater management in rural and suburban areas in Jordan.

To achieve the main goal of this collaboration, MWI formed a multi-sectorial committee (the National Implementation Committee for Effective Decentralized Wastewater Management in Jordan – NICE), and accordingly established an implementation project-office in MWI (NICE Office) to follow up on this pioneer effort in Jordan. The committee includes fifteen members and five observers. The primary fifteen members are ten representatives from governmental institutions, mainly ministries, and five members from national and international academic and research institutions. On the other hand, the five observers represent international agencies with great interest and significant profile in the topic. Collectively, the twenty individual members are experts in the field of water resources in general and with the focus on wastewater treatment and management.

This framework provides the regulatory, managerial and technical foundation towards implementing a decentralized approach to managing wastewater in Jordan. Such an approach focuses on wastewater services that are robust, efficient, equally convenient, cost effective, environmentally responsible and responsive to water scarcity. Objectives associated to extending Jordan's wastewater services following a decentralized approach include the protection of Jordan's groundwater resources from contamination with untreated wastewater in order to ensure national drinking water supply, the advancing of the potential for fresh water substitution (reuse, managed aquifer recharge), and the further improvement of sanitation and public health. Meeting these objectives will certainly contribute to the national progress towards achieving the UN Sustainable Development Goal (SDG) 6: *"Ensure access to water and sanitation for all"*.

The committee views decentralized wastewater management as complementary approach to centralized wastewater management. In fact, while centralized wastewater treatment plants have been proven to be an appropriate approach for large communities in Jordan, it is concluded that they may be less appropriate for small communities and suburban areas than decentralized systems because connection costs and risk of technical failure are realized to be increased with remoteness and dispersion of communities. Overall, decentralized wastewater structures should be established where they achieve greater economic and social benefits than centralized solutions. In this manner, rather than serving as a substitute, they complement centralized systems in order to optimize the national wastewater management system.

The framework categorizes decentralized wastewater management to include the treatment of wastewater generated in individual isolated houses, groups of houses (neighborhoods) or larger catchment areas (small communities). For the decentralized wastewater classifications and management cluster, the term "decentralized" denotes wastewater collection, treatment and reseat or near the point of wastewater generation, so that additional costs for transportation or pumping of water are avoided to the greatest extent possible. The treatment is traditionally divided into three main categories; On-site designed for less than 50 population equivalents (individual building or property), Decentralized Type-I designed for 50 to and less than 500 population equivalents (neighborhood), and Decentralized Type-II designed for more than 500 to under 5,000 population equivalents (small community).

Many decentralized wastewater management systems consist of a diverse set of wastewater treatment plants servicing the population of a defined area in the form of **decentralized wastewater management cluster**. The feasibility study on decentralized wastewater treatment and reuse clusters on regional scale in Jordan, conducted on 2014 provides clear examples on decentralized wastewater management clusters.

On the outline and areas of application of this framework, the framework is concerned exclusively with domestic wastewater in Jordan. Wastewater from other activities is not considered. Furthermore, the framework refers to specific ranges for raw wastewater qualities that refer among others to the most important quality parameters, i.e. Biological Oxygen

Demand (BOD5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and Total Nitrogen (TN). Detailed information on the wastewater characteristics are presented in the framework.

In the Framework several bottlenecks toward sustainable implementation of decentralized wastewater management systems in Jordan are identified and addressed. To tackle these bottlenecks, technical groups for each topic developed the associated chapter. The technical groups include national and international experts with the specific experience required to develop the framework. The content of the framework chapters and core measures are summarized in the following table:

Chapter	Framework	Core Measures
Groundwater protection	Definition of groundwater "hot spots" in support of protection zones	1. To establish DWWM at hot spots 2. To amend Art. 8(A) Wastewater Regulation 66/1994 (cesspools)
Economic Feasibility	GIS-based dynamic cost comparison identifying best wastewater solutions	1. To apply economic feasibility tool to generate best solutions 2. To establish micro-financing versus Art. 9 Wastewater Regulation 66/1994 (household connection)
Urban Planning	Integrating urban & infrastructure planning	1. To cap vertical housing expansion 2. To integrate housing and wastewater planning for new development projects
Participatory Planning	Community-led Urban Environmental Sanitation Planning	To establish PP for community wastewater and reuse projects
Technology Selection	5-Step Multi-Criteria Technology Selection Procedure	1. To establish 5-step selection procedure for all wastewater projects 2. To establish a technology certification procedure by 2020 3. Revision of technology selection every 5 years
Standards and Monitoring	Effluent values & control schemes for demand-specific reuse for WWTPs < 5,000 PE	1. To issue demand-specific effluent standard for WWTPs < 5,000 PE 2. To establish a public regulator for WWTPs < 5,000 PE 3. To establish Pre-EIA for WWTPs < 2,000 PE

Operation and Maintenance	Contract options for 1st decade of operating DWWM	1. To establish full O&M coverage contracts or full-labor contracts if full O&M contract successful ≥ 6 years 2. To revise & issue a list of qualified O&M providers (contractors & service companies) for DWWM in Jordan annually
General Measures	Measures on the system level	1. Future role of NICE 2. Capacity Development Measures for DWWM in Jordan

I. Rationale and Principles of the Policy Framework

Due to intense immigration and climate change (uncertain and variable precipitation) water scarcity will accelerate and therefore sustainable management of water resources is a key determinant of Jordan's future.

The average population growth in Jordan - not accounting for migration to Jordan, e.g. dislocated population from Syria - is about 2.2 percent (2011). Due to its geopolitical situation, Jordan is the second refugee host country in the Middle East. Since 2013 the population has risen from 6.46 million to 8.0 million people (OECD/World Bank 2015) posing immense pressure on Jordan's resources, including water.

Increasing overall water extraction to meet increasing demand is not sustainable as Jordan is now using its non-renewable water resources (fossil deep-water aquifers). The abstraction rate of groundwater aquifers in Jordan is twice as high as their recharge rate. The overall recharge rate is 231 MCM, the abstraction rate is 588 MCM including abstraction from the Disi aquifer (non-renewable water) and 419 MCM excluding the abstraction of the Disi aquifer (Jordan Water Budget 2014).

Pollution of aquifers is often very high, especially in rural areas, where wastewater infiltrates through leaking septic tanks or cesspits. As the average domestic water consumption is low (country wide average is around 70 lpcd) wastewater in Jordan features very high organic loads and a higher than normal wastewater salinity.

Centralized wastewater treatment plants have been proven to be a suitable approach for large communities in Jordan and significantly contribute to Jordan's water budget. In 2014 the amount of the wastewater treated at centralized WWTPs was 137 MCM of which a total of 125 MCM was reused as follows: 123 MCM for agriculture and 2 MCM for the industrial sector in Aqaba (source: Water Budget 2014). For wastewater management of small communities centralized approaches may be inappropriate. Jordan’s topography is highly variable and poses a major challenge to planning and maintaining extensive conveyance structure (e.g. pipelines, networks, roads, etc.) so that sewage connection costs and risk of technical failure increase strongly with remoteness and dispersion of settlements. While accelerated extension of wastewater services to small communities is essential to address serious concerns over water scarcity, pollution, and public health, such measures should focus on systems that are robust, efficient, cost effective, environmentally responsible and responsive to water scarcity. Decentralized wastewater management systems can be used on household scale, clusters of houses or larger catchment areas and close to the point of wastewater generation, so that additional costs for transportation or pumping of reclaimed water are avoided to the greatest extent possible. Thus, decentralized approaches to wastewater management, can play an important role in achieving a more sustainable water resources management in the Kingdom. Rather than serving as a substitute for centralized plants, decentralized wastewater structures are complementary solutions at locations where they achieve greater economic and social benefits than centralized systems.

A. National Implementation Committee for Effective Wastewater Management in Jordan (NICE)

With funding from the German Ministry of Education and Research (BMBF) under the “Integrated Water Resources Management” sponsorship program (02WM1212), the Jordanian Ministry of Water and Irrigation (MWI) and the UFZ have set up an Implementation Project Office on the premises of the ministry designed to co-ordinate the development of a Framework for the implementation of decentralized wastewater management in rural and suburban areas over the period 06/2012 to 12/2015.

The joint Jordanian-German initiative aims to integrate the relevant institutions and technologies into the current political strategy of Jordan while also considering the socio-economic environment and the country specific conditions required for successful implementation. Within the frame of the project the Ministry of Water and Irrigation has established the National Implementation Committee for Effective Decentralized Wastewater Management in Jordan (henceforth: The National Implementation Committee or NICE) in 2013. The main objective of the National Implementation Committee is to develop the implementation strategy, where the interests of all major stakeholders of Jordan are represented. Established experts and corresponding local and international networks are involved to help create the fundamental conditions required for decentralized wastewater treatment and reuse systems.

The NICE Steering Committee consists of representatives of the main public stakeholders (ministries, authorities and agencies) as well as representatives of research and science institutions with strong expertise in the field (see Figure 1).

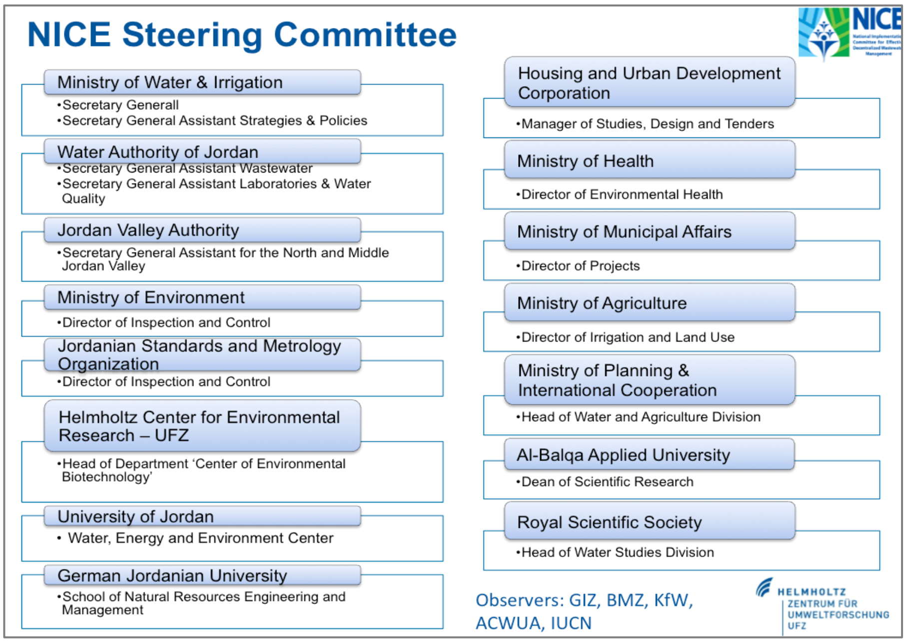


Figure 1: Institutions represented in the National Committee for Effective Decentralized Wastewater Management in Jordan

B. The Tasks of the National Implementation Committee

The specific tasks of the National Implementation Committee are as follows:

- To facilitate decentralized treatment and reuse of domestic wastewater in Jordan for the purpose of groundwater protection and fresh water substitution and complementary to centralized treatment
- To prepare a framework document (henceforth: NICE Framework) that addresses the main requirements of sustainable decentralized wastewater management in Jordan that is produced by and in consensus of the main stakeholders in the area of wastewater management.
- To provide a major contribution to the ongoing process of defining official guidelines, policies and national regulations for sustainable decentralized wastewater management in Jordan.
- To provide guidance for future investment projects for decentralized wastewater infrastructure and management schemes.

The method of working in order to achieve the set objectives of NICE involves four main elements. Firstly, the Committee is conceived as an inter-sectorial round table that brings together national stakeholders in the area of wastewater and reuse management. It was established based on Terms of Reference agreed upon by all its members. The steering committee defines technical topics and their priorities relevant for decentralized wastewater management in Jordan. It has devised a common work plan and working procedures that facilitate the joint production of the NICE Framework. The steering committee is responsible issuing the NICE Framework.

C. The NICE Framework

The addressees of the NICE Framework are ministries and public authorities of the water sector in Jordan and in other water scarce countries, as well as municipalities, NGOs, education and research institutions, international donors, and private sector companies in the water sector.

The main purpose of the NICE Framework is to enable the sector to better manage its decentralized wastewater systems. . Over the last three years the National Implementation Committee discussed thoroughly decentralized wastewater management among themselves as well as with sector stakeholders and international donor organizations.

For sustainable implementation of decentralized wastewater management systems existing bottlenecks need to be tackled. These have been identified by the NICE Steering Group and are addressed in the respective chapters of the NICE Framework (see Figure 2).

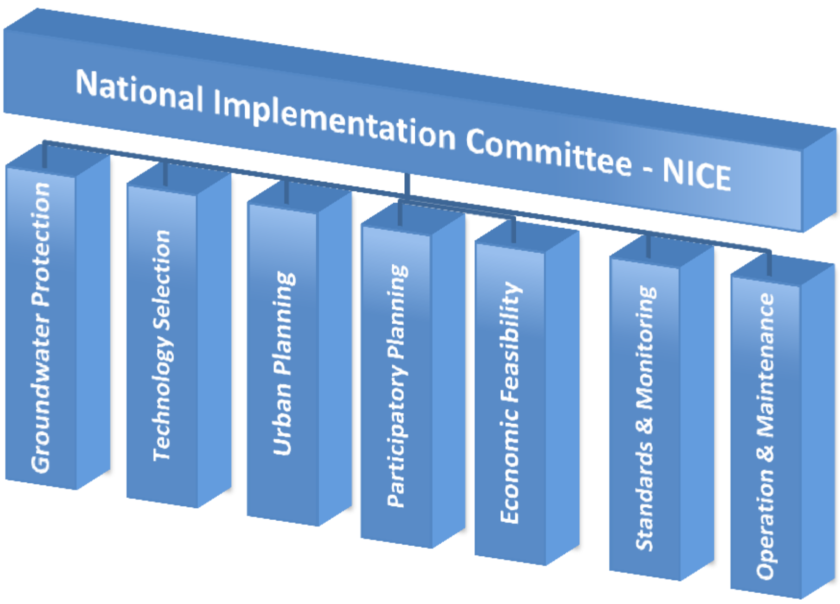


Figure 2: Framework Topics of the National Committee for Effective Decentralized Wastewater Management in Jordan

D. Scope and Field of Application of the NICE Framework

The NICE Framework is concerned exclusively with domestic wastewater in Jordan. Wastewater from commercial and industrial dischargers, military facilities, and processing of agricultural products (e.g. olive oil mills) are not considered.

The NICE Framework considers specific ranges for raw wastewater qualities of domestic wastewater for Jordan (see Table 1).

Table 1: Ranges for raw domestic wastewater characteristics in Jordan

Parameter	Unit	Estimation	
		Min. value	Max. value
Biological Oxygen Demand (BOD_5)	mg/L	600	1500
Chemical Oxygen Demand (COD)	mg/L	1000	2500
Total Suspended Solids (TSS)	mg/L	600	1500
Total Dissolved Solids (TDS)	mg/L	800	1300
Total Nitrogen (TN)	mg/L	30	150
Total Phosphorus (TP)	mg/L	20	80
Fat, Oil, Grease (FOG)	mg/L	48	206
Sulphate (SO_4)	mg/L	200	400
E. Coli	MPN/100mL	$2.3x10^4$	$9.2x10^7$

Source: Adapted from Feasibility Study on Decentralized Wastewater Treatment and Reuse Clusters on Regional Scale in Jordan 2014

Since, in this framework WWTPs with a capacity below 5,000 Population Equivalent (PE) are typically considered “decentralized” solutions, it does not apply to WWTPs with a capacity greater than 5,000 PE. However, clusters of different neighboring WWTPs with a design capacity of up to 5,000 PE are considered decentralized wastewater management systems (see Figure 3).

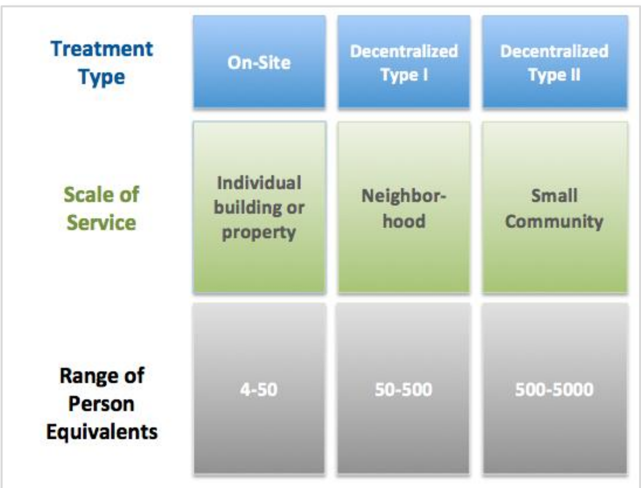


Figure 3: Typical Sizes and Classification of DWWT solutions for Jordan

According to the size of project areas several clusters can be managed together. Thus the maximum amount of P.E. can be increased according to the project area.

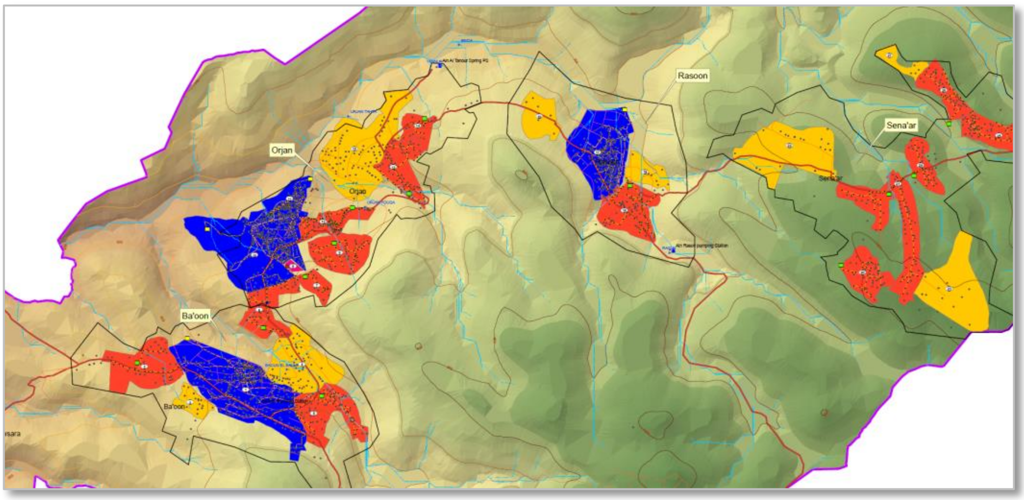


Figure 4: Example of a Decentralized Management Cluster for Ajloun Governorate to protect the Al-Tannour Spring, source: "Feasibility Study on Decentralized Wastewater Treatment and Reuse Clusters on Regional Scale in Jordan" (2014)

II. Wastewater Management for Improved Groundwater Protection

The protection and maintaining of water resources at suitable quality are urgent national needs for the best management and the optimal use of scarce resources, by applying a national policy for the protection of groundwater and surface water resources in order to restrict the access of pollutants to water resources.

In this respect the Drinking Water Resources Guideline, proposed by BGR in 2002, was issued in 2006 and updated in 2011 by the Ministry of Water and Irrigation. In 2012, protection of groundwater against contamination from mining activities was added. Recently the Environment Law, to which this guideline is referenced in various paragraphs, was accepted by the Cabinet.

One of the core measures to protect water resources (springs, wells and reservoirs) from bacteriological, organic and nitrogen contamination is the establishment of wastewater collection and treatment systems.

Wastewater collection and treatment systems have been expanded during the past two decades, and currently cover predominantly the urban centers. In Jordan, wastewater management systems are most beneficial where they support the protection of groundwater, and the main fresh water resource and in particular where they facilitate the implementation of groundwater protection zones. In the case of Jordan, such an approach when applied properly maximizes the benefits of wastewater collection and treatment for the country's water resources protection. Proper application requires the following measures and actions:

1. To identify areas where groundwater would benefit most from wastewater treatment, so-called hot spot areas, where groundwater is being contaminated and/or is at high risk of contamination from untreated domestic wastewater.
2. To develop recommendations for wastewater treatment in groundwater protection zones, that include careful assessment of risks and benefits of wastewater treatment in groundwater protections zones, site selection criteria accounting specifically for hydrological and geological characteristics of the protection zone, and safety considerations for the selection of sites for wastewater collection, treatment and discharge facilities, treatment technologies, treated wastewater reuse, and sludge management in groundwater protection zones.

A. Hot spots of groundwater contamination from domestic wastewater

The identification of hot spots of groundwater contamination from domestic wastewater includes the following three steps.

1. Hot Spot definition and criteria
2. Hot Spot mapping and prioritization of hot spots
3. Site selection principles for wastewater treatment in groundwater protection zones

1. Hot Spot definition and criteria

For the purpose of this framework, groundwater hot spots are defined as areas that have caused or are expected to cause contamination to the groundwater resource nearby through, e.g. leakage of domestic wastewater from cesspools, septic tanks, or sewage networks or through inappropriate handling of wastewater.

In order to accurately identify the source of contamination the following provenances of contamination need to be taken into account when identifying a hot spot:

Table 2: Main provenances of contamination of drinking water sources in Jordan

Main categories of pollution	Features
Collateral pollution	
Pollution risks due to infiltration to the groundwater aquifer (known infiltration points)	Potential sources of pollution such as feces and other pollutants that may directly impact the water resource (e.g. cesspool located near water resource, leakages in the sewage network in a groundwater protection zone)
Path pollution	
Risks along the drinking water production and supply line	Potential entry of pollutants to the water supply path (example: the eroded backfill areas of protected springs, leaking pipes or intermittent pumping).
Unverified pollution	
Pollution risks due to unknown infiltration of wastewater to the groundwater	Potential entry of pollutants due to lack of control measures (e.g. offload of sewage suction vehicle cargo in wadis)

The identification of such hot spots is based on the Jordanian “Microbiological Guideline for the Quality of Raw Water for Drinking Water” issued by the Higher Committee for Water Quality in 2011.

For the impact of domestic wastewater on groundwater, biological agents such as E.Coli, are the main indicator for contamination. In addition the following data needs to be assessed in order to identify the risk of pollution.

- Collection of quality status of all protected public and private drinking water sources, groundwater aquifers and springs (name, operator, location, pumping rates, status/volume of resource, technical description) by Governorate. The status of the recharge area, the source productivity and its risk of pollution is based on available testing results for several years for raw water of the concerned authorities (i.e. Ministry of Health, the Ministry of Environment and the Ministry of Water and Irrigation, the Water Authority, the Jordan Valley Authority).
- Hydrological, hydrogeological data and environmental isotope data for the water resource to derive flow patterns, aquifer characteristics, and static water levels in order to identify the source of pollution based the groundwater flow, the drainage in the catchment area and the recharge zone, the degree of sewage connection and the associated potential for wastewater infiltration from leaking cesspools and networks.
- Data on water delivery services i.e. piped water supply or by tanker, average water consumption per capita as well as water use in agriculture, for landscaping and industry.

2. Hot Spots and vulnerable water resources for all Governorates of Jordan

Based on the above information and data, GIS-based maps were produced to identify the current hot spots in Jordan for contamination with domestic wastewater.

Table 3: Hot spots and vulnerable water resources for all Governorates as of 2014

Governorate	Hot spots		Settlements	Population in 2009	Water Resource		Category of Pollution
	Current	*Future*			*Spring*	*Well / well field**	
Irbid		✔	Al-Muagyyer	9.946	Rahoub		collateral
			Harima	4.233		Harima	
Ajloun	✔		Ain Janna	10.147	Al-Qantara		collateral
		✔	Orjan, Rasoon	5.865	Tannour		
			Rassoon	2.405			
Jerash	✔		Gaza Camp	16.611	Ain Al Teis & Ain Al-Deek		collateral / path
			Kitteh	6.826			
			Central Jerash	14.690	Qairawan		
Balqa	✔		Center of Salt	95.700	Azraq		collateral / path
			Maheis	12.316	Bqouriyya & Fuheis		
			Fuheis	13.464			
Zarqa	✔		Al-Qunayyah	641	Al-Qunayyah		collateral
			Beareen	1.368		Bareen	
			Al-Rusayfah City	265.365		Al-Rusayfah*	path
		✔	Aalouk	765	Alouk		collateral
Amman	✔		Ras Al-Ain	109.269	Ras El-Ain		collateral
			Wadi El-Sir	145.504	Wadi El-Sir		
			Shafa Badran	18.282		University	collateral / path
Madaba	✔		Mulaih & Rashidiyya	7.132		Hidan*	collateral
Karak		✔	Salihiyya	573	Sarah		collateral

Of these hot spots those with the most severe conditions were prioritized for implementing sewage solutions in the settlement from which the contamination originates and according to the importance of the respective water resource for drinking water supply as well as its vulnerability to surface pollution.

- Aalouk village in Zarqa Governorate to protect the Aalouk spring
- Ain Janna village in Ajloun to protect the El-Qantara spring
- Kitteh village in Jarash Governorate to protect the Ain Al-Teis and Ain Al-Deek springs
- Villages of Ra'soon and Orjan in Ajloun to protect he Tannour spring

B. Principles for wastewater management in Groundwater Protection Zones

Through technical cooperation between the Ministry of Water and Irrigation and the German Federal Institute for Geosciences and Natural Resources (BGR), a guideline has been issued in the year 2011for the protection of water resources (reference BGF Guideline). Twentyone

(21) protection zones are identified including ten (10) well fields, nine (9) springs and two (2) dams (2015).

Protection zones are divided into three zones, with a different level of land use restrictions for each zone: Protection Zone I protects the dam, well or spring from direct pollution. Activities in zone 1 are limited to the operation of the dam, well or spring. Protection Zone 2 protects water resources from microbiological contamination, i.e. bacteria and viruses. Activities in Zone 2 are limited to human living activities and organic agriculture. Protection Zone 3, protects the water resource's catchment area by controlling its developmental, industrial, and agricultural activities.

Despite the positive effects of wastewater treatment for groundwater protection from collateral pollution, e.g. leaking cesspools, new WWTPs are to be planned carefully as regards to possible adverse effects on groundwater. To identify most adequate treatment sites the hydrogeological and hydrological information and where available, groundwater vulnerability maps, are to be considered.

1. Site selection for wastewater treatment

Due the prevalent karstic geology and ensuing high vulnerability to pollution, the establishment of wastewater treatment facilities is confined to Protection Zone 3 given that additional requirements are fulfilled, i.e. selecting the least vulnerable location within Protection Zone 3. Furthermore, treated effluents should not be discharged in to wadis leading to Protection Zone 2 (see JS 893/2006 6-1-2).

For this vulnerability maps are to be consulted. Since 1996, BGR has prepared a large number of individual groundwater vulnerability and hazards maps for areas with rapid urban growth and contamination risks, which reflect the natural protection of the aquifers and the risks prevailing at the time of map preparation. BGR is currently in the process to prepare a unified groundwater vulnerability map for one third of the country which will be integrated into the landuse planning atlas for landuse licensing decisions.

In this context, especially land stability, flooding risk and potential negative impacts by georisks need to be considered. Wastewater collectors, passing through Protection Zone 2, musts be designed in such a way, that they cannot cause pollution, e.g. through damages by georisks (rockfalls, landslides, earthquakes, tectonic movements). A specific guideline for

EIAs of wastewater facilities in karst areas has been developed by BGR and should be applied here.

2. *Reuse*

When reusing treated wastewater, e.g. in agriculture, the applicable regulation, i.e. the Jordanian Standard for Reuse, currently JS 893/2006, is to be complied with. For reuse of treated effluent originating from WWTPs with a capacity below 5,000 population equivalents (decentralized wastewater treatment), reuse shall be performed following the quality parameters for treated effluent as suggested under section 0 "Regulatory specifications and programs for treated domestic wastewater from treatment plants with a capacity below 5,000 population equivalents" in this Framework.

3. *Discharge*

The open discharge of treated effluent to the valleys adjacent to the Protection Zones 1 and 2 is prohibited by Article 30A/3 in Water Authority law no. 18 of 1988 and amendments thereof.

4. *Managed Aquifer Recharge*

In general, it is allowed to use treated effluent for the purposes of artificial recharge provided that the water in the aquifer is used for irrigation purposes only. Technical studies must be performed before using reclaimed water to verify that there is no effect on groundwater aquifers used for drinking purposes (see JS 893/2006 paragraph 6-2-1-3)

For aquifers used for drinking water supply, managed recharge of treated water is prohibited in Protection Zone 2 and 3 due to its negative impact on water resources. However, in view of the extreme and increasing water scarcity in Jordan, it is worthwhile examining each case separately and to establish exceptional cases, e.g. in Protection Zone 3, where feasible. For this, a feasibility study with a detailed analysis of the hydrogeological situation that must include an investigation of groundwater travel times. Furthermore, the following WHO study must be consulted, "State of the Art Report on Health Risks in Aquifer Recharge Using Reclaimed Water" (WHO/SDE/WSH/03.08).

C. Measures

In order to put into effect groundwater protection from domestic wastewater the following measures shall be taken:

Measure 1: To establish with urgency wastewater treatment for the identified hot spots in order to protect vital groundwater resources from pollution with domestic wastewater.

Measure 2: To connect in future all houses with impermeable cesspools to sewer wherever new wastewater collections systems are established.

Measure 3: To establish a strategy for cooperation between the municipalities and the Water Authority for enforcement of wastewater regulations.

Measure 4: As a measure essential to make groundwater protection from domestic wastewater possible, a wastewater regulation that solves the issue of ”permeable cesspools” in Jordan, and in particular the revision of Article 8 (A) of the National Wastewater Regulation 66/1994 shall be implemented. Article 8 (A) states that *"If a private wastewater sewer cannot be connected to the public wastewater sewer for any reason whatsoever, the owner shall construct at his own expense within the boundaries of his property an absorption pit and/or septic pit in accordance with such instructions and standards as shall be determined by the local council in certain areas in coordination with the Authority."* In the National Wastewater Regulation 66/1994, Article 2 the item "Absorption Pit" is defined as *"A pit set aside for all the water extracted from liquid waste and for the drainage thereof through soil cracks and pores"*.

D. Responsible parties for implementing above Measures

The Water Authority and any other agency responsible for implementing a wastewater management project in Jordan such as the Housing and Urban Development Company, Jordanian municipalities, international donors, and urban developers are responsible parties for implementing Measure 1 and Measure 2.

The Ministry of Water and Irrigation shall be responsible for implementing Measure 3.

The Ministry of Water and Irrigation and ultimately the Government of Jordan shall be responsible for implementing Measure 4.

III. Economic Feasibility of Wastewater Management Systems

The design of technologically sound and cost-efficient wastewater solutions is a challenge for any wastewater infrastructure planner in any country. Finding the most adequate size and configuration of wastewater infrastructure will determine the cost-efficiency of the investment as well as the expenditures for operation and maintenance throughout the system's entire operational life-time. Hence, the development of wastewater infrastructure projects should be based on comprehensible data and realistic assumptions.

A. Assessment of Local Lowest-Cost Wastewater Solutions (ALLOWS)

In order to identify most cost-efficient wastewater management solutions and to determine whether a centralized or a decentralized approach is economically more appropriate for a specific case, a decision-support tool shall be applied. To this end a tool, the so-called "Assessment of Local Lowest-Cost Wastewater Solutions" (ALLOWS) tool, has been developed by the Helmholtz Center for Environmental Research (UFZ). Its application in Jordan has been established by the SMART project (Sustainable Management of Available Water Resources with Innovative Technologies), funded by the German Federal Ministry of Education and Research, as well as by the "Feasibility Study on Decentralized Wastewater Treatment and Reuse Clusters on Regional Scale in Jordan" by the example of five villages in the Governorate of Ajloun *(see also van Afferden M., Cardona J. A., Lee M.-Y., Subah A. and Müller R. A. (2015). A new approach to implementing decentralized wastewater treatment concepts. Water Science & Technology, doi:10.2166/wst.2015.393)*. The study was commissioned by UFZ for the Ministry of Water and Irrigation to the company Dorsch International Consultants Ltd. in Jordan. ALLOWS combines data generated via Geographic Information System (GIS) software and cost data in order to perform a Dynamic Cost Comparison (DCC) of different feasible wastewater management scenarios for any given local demographic and physical wastewater context. The ALLOWS analysis is particularly fit to achieve the following:

- To design highly flexible local wastewater management solutions for fast growing conurbations.
- To develop local wastewater management solutions that grow alongside changing demographic and wastewater conditions.
- To reduce cost for wastewater disposal in rural and suburban areas, for which long-distance sewerage to centralized treatment is usually prohibitively expensive.

- To overcome the challenges of topographical conditions of centralized solutions that require costly pumping stations that are often prone to failure
- To optimize investment costs and operation and maintenance requirements by means of generating economy of scale for local wastewater solutions.

ALLOWS generates financial indicators for different wastewater scenarios and thus enables planners and decision-makers to perform a comparative analysis to identify best solutions for the wastewater management problem at hand. Main factors that are required for finding sustainable solutions to wastewater problems are integrated in the analysis. These are: Current and projected long-term demographic developments, connection degree, groundwater status and vulnerability to pollution from domestic wastewater, local reuse options (land use), potential treatment technologies based on local wastewater quantity and quality, existing infrastructures (sewage networks, centralized treatment plant, cesspools/septic tanks) and geographical conditions (topography, natural drainage). With these factors different decentralized scenarios are developed, monetized and compared to the cost of a centralized solution.

1. ALLOWS Scenario Development and Comparison

The ALLOWS scenarios are built based on the following operations:

- Estimating the required treatment capacity for wastewater solutions using data that allow estimating the specific wastewater quantity and quality, population statistics and data on land ownership to project housing development.
- Identifying micro catchments on settlement scale that allow for wastewater conveyance without or with minimal pumping (gravity flow sewer networks).
- Designing urban infrastructure clusters for wastewater management scenarios.
- Estimating costs of construction, operation and maintenance (O&M) and reinvestments for different wastewater management scenarios.
- Generating annualized cost for each scenario and determining their cost-efficiency by means of comparison among different scenarios.
- Optimizing cluster sizes to minimize O&M cost of wastewater management systems.

The GIS-based assessment involves a geo-database, fed with geographical, urban, socio-economic, and statistical data of the area of interest. This geo-database contains satellite imaging to determine the area's physical infrastructure, the number of residents per building, land use data to identify reuse options, potential plots for WWTPs (e.g. undeveloped municipal land), topographical conditions, gravity flow information through combining the geo-database with digital elevation models, land ownership (e.g. parcel index), international and national benchmark prices for all cost items (treatment technology, reuse infrastructure, network construction, pump and lifting stations, operation and maintenance labor, electricity and water, etc.).

The assessment generates financial indicators for different wastewater scenarios that enable planners and decision-makers to perform a comparative analysis so as to identify best solutions for the wastewater management problem at hand. Main factors that are required for finding sustainable solutions to wastewater problems are integrated in the analysis. These are: Current and projected long-term demographic developments, connection degree to sewer networks, groundwater status and vulnerability to pollution from domestic wastewater, local reuse options (land use), potential treatment technologies based on local wastewater quantity and quality, existing infrastructures (sewage networks, centralized treatment plant, cesspools/septic tanks) and geographical conditions (topography, natural drainage). With these factors different wastewater scenarios are developed that can be monetized and compared among each other.

2. ALLOWS Cost Analysis

ALLOWS scenarios are compared using the Total Project Value (TPV) method elaborated by the guideline of the German Association for Waste, Water and Wastewater (German: Deutsche Vereinigung für Abfall, Wasser und Abwasser - DWA e.V.) for costs comparison of wastewater infrastructure projects (DWA 2012). Scenarios are compared in terms of TPV and Specific Treatment Costs calculated in Jordanian Dinar per cubic meter treated wastewater (JOD/m^3) in order to reveal the economic competiveness of the different wastewater management scenarios.

At applying the TPV method to ALLOWS scenario analysis the following cost components are calculated: Total Capital Cost, Reinvestment Cost, O&M Cost . A discount rate ranging from 3% to 5% and a 25 to 30-year project period should be assumed in order to determine the total financial scope of each solution for different macroeconomic conditions.

Total Capital Cost represents all infrastructure components required to build a treatment system. This involves mechanical and electrical components of a WWTP and the associated civil work. Expenses that are not directly associated with the construction of WWTPs are included as ‘Other Cost’ and cover land acquisition costs, cost for construction of administrative buildings, engineering design cost, overheads, profits and contingencies. For each technology in the scenarios a specific cost function is to be developed. Cost functions allow modeling of different possible WWTP capacities and are widely used estimating cost of wastewater infrastructure (Tsagarakis et al. 2003; Friedler & Pisanty 2006; Nogueira et al. 2007). Operation and maintenance cost for all scenarios include cost for personnel, energy consumed by electrical devices (pumps, aerators, ultraviolet lamps), laboratory analysis as well as sludge treatment. All personnel cost are calculated in JOD/month. O&M costs should be based on actual Jordanian salaries and current energy prices in Jordan (for 2014: 0.05 JD/kWh). In addition, spare parts are included assuming 9% of total annual O&M cost (Tsagarakis et al. 2003).

Reinvestment cost are calculated based on the “Guidelines for performing dynamic cost comparison“ (DWA 2012), considering 40% of the construction cost for replacements in the years 12 and 25 and 60% of the construction cost for reconstruction after 25 years.

In order to compare different scenarios, the calculated TPVs are annualized and the cost expressed as annual cash flow over the entire project period, i.e. 30 years. The annualized cost (AC) indicator also provides the possibility to compare scenarios by means of Specific Treatment Cost that represent the total cost per cubic meter of treated wastewater.

3. ALLOWS Decision-Support Tool

The ALLOWS GIS-based decision-support tool allows the following:

- Comparing different wastewater project options via TPC based on actual market values covering all investment, re-investment and O&M cost over the operational life of a system.
- Applying scenario analysis to compare different wastewater management solutions.
- Providing a treatment and reuse solution that is appropriate and feasible for the actual local wastewater context.
- Achieving the targeted connection degree alongside the projected population dynamics over a system’s life-time (~20 to 30 years).
- Prioritizing investment decisions based on TPC only instead the initial capital investment.
- Adapting wastewater solutions to natural conditions such as topography and natural drainage in order to minimize infrastructure requirements (pumping, sewerage).

- Closing local water cycles by exploring on-site reuse opportunities (irrigation, managed aquifer recharge, landscaping, forestry) to substitute precious fresh water resources.

B. Measures

1. The ALLOWS decision-support tool shall be applied to the development of all wastewater management solutions in Jordan in order to assess whether a centralized or decentralized approach is more feasible at a specific location. The reference study for this is the *"Feasibility Study on Decentralized Wastewater Treatment and Reuse Clusters on Regional Scale in Jordan"*.
2. Where more economical than centralized treatment, decentralized wastewater management solutions with capacities lower than 5,000 population equivalents per treatment facility, shall be implemented and vice versa.
3. The burden of settling the cost incurred by way of Article 9 of the Wastewater Regulation 66/1994[1] shall be eased through micro-finance schemes to be set up on community level. Among other requirements, the "Wastewater Regulation No. 66" (issued in 1994 based on the Water Law No. 18 of 1988) obliges property / house owners to connect to public sewers and bear the related cost (connection fee of 25% of the property's estimated net annual rental value and installation of a wastewater lifting pump in case wastewater cannot flow by gravity to the public sewer outside the property).

C. Responsible parties for implementing above Measures

The Water Authority and any other agency responsible for implementing a wastewater management project in Jordan such as the Housing and Urban Development Company, Jordanian municipalities, international donors, and urban developers are responsible parties for implementing Measure 1 and Measure 2.

The Ministry of Water and Irrigation and the Water Authority shall be responsible to implement Measure 3 and specifically for engaging international donors in such micro-financing schemes.

[1] "The property owners shall settle the fees and charges to be paid and complete the connection of the private sewer to the public sewer within three months from the date the decision is published in accordance with paragraph A of this article. The works shall be carried out at the owner's expense by contractors classified by the Ministry of Public Works & Housing and registered with the Authority in accordance with such standards and directives as it shall prescribe."

IV. Urban Planning for Wastewater Management

The lack of holistic schemes for urban planning has led to an imbalance in distributing the country's development gains. There is an urgent need to adopt a flexible urban planning to improve land management thus tackling many problems of Jordan among others the increased pressure on infrastructure and existing resources due to the progressive increase in population. One major aspect at that is to link urban and land use planning with infrastructure planning.

Wastewater infrastructure and urban planning need to be integrated across responsible authorities in order to manage housing development and the development of wastewater infrastructure more efficiently and sustainably. Implementation of wastewater projects are likely to face land acquisition problems as they are not included in current planning procedures for residential areas as alternative systems for often insufficient septic tank treatment.

A. Characterization of Urban Planning in Jordan

The planning process in Jordan is considered to be highly centralized. Although the law specifically allows municipalities to execute and apply city planning, the Ministry of Municipal Affairs (MoM) has already developed inclusive schemes for all of them, as it is the most competent authority in this field while municipalities usually do not have this capability. Hence, municipal councils were given limited responsibility in this regard. Planning decisions are presented through committees for public comment as a legal duty rather than an effective attempt made by the municipal council to identify the priorities and requirements of the residents.

The main problem areas of planners due to planning irresponsive of local conditions can be classified into four categories:

- Problems of providing infrastructure and basic services.
- Problems of pollution resulting from urban wastes and emissions.
- Problems of resources deterioration.
- Problems of environmental hazards.

There is an urgent need to move away from centralized and land use planning and for planning tools appropriate for the individual needs and resources of Jordan's municipalities. This could be achieved by a new planning law drafted in 2010. Among others it envisages to link physical planning with infrastructure planning, and to develop a timetable for implementation involving an infrastructure planning system and committees at the municipal level with representatives of the relevant authorities for planning. The new planning law draft is subject to consideration since 2010.

B. Bottlenecks of wastewater infrastructure planning from a urban planning perspective

The bottlenecks of infrastructure planning and sustainable infrastructure operation from a urban planning perspective are manifold and diverse and can be clustered by four groups:

1. Institutional framework
    a. Absence of a modern and holistic law for urban planning in Jordan
    b. Lack of clear allocation of responsibilities and funds for urban planning at responsible administrative levels and among concerned authorities (municipalities, governorates, ministries)
2. Uncontrolled expansion and migration
    a. Uncontrolled and unplanned horizontal and vertical expansion of residential areas often distant to public infrastructure due to lack of control
    b. External population growth (displaced persons) which results in new residential areas beyond the national planning frame (refugee camps)
3. Coordination
    a. Inefficient or lack of coordination among public authorities in the area of land use
    b. Land acquisition problems for establishing new WWTP as they are currently not included in residential planning schemes
4. Technical obstacles due to existing inappropriate wastewater infrastructure
    a. Inappropriate wastewater infrastructure already in place in many rural and suburban residential areas (infiltrating cesspools) that will make it difficult to argue for investment in more appropriate wastewater systems

C. Recommendations for Urban Planning

1. Recommendation 1: To stipulate and enforce a national planning law that covers all land uses and is based on state-of-the-art urban planning methods and tools
2. Recommendation 2: To establish one planning umbrella for land use and urban planning in Jordan or one existing regulatory body or the Higher Council alone shall be solely responsible for urban planning.

3. Recommendation 3: To entrust the planning process to planning specialists in order to consider all dimensions and state-of-the-art planning standards including the integration of all vital infrastructures, i.e. water supply and wastewater disposal, transportation, electricity, etc.
4. Recommendation 4: Indiscriminate expansion of cities shall be reduced through comprehensive development schemes and respective urban plans as well as the control and enforcement of implementation of these schemes.

D. Measures for Integrating Wastewater Planning with Urban Planning

1. The urban policies of vertical concentration shall allow specific reasonable rates to reduce cost of horizontal expansion, taking into account the requirements of vertical construction and the capacities of existing and planned wastewater management systems.
2. Establishing stakeholder committees for infrastructure planning at the municipal level and a timetable for implementation of infrastructure projects.
3. Wastewater management systems shall be included in the planning schemes of new or current residential areas. Priority shall be given to settlements that have been defined as groundwater hot spots (see section II.A.2).
4. When planning for wastewater infrastructure, urban planners shall integrate suitable and adapted wastewater treatment options, as listed in the Technology Selection Procedure, that fit the recommended effluent qualities for the reuse of treated wastewater.

E. Responsibilities to implement above Measures

The implementation of Measure 1 and Measure 2 depend on the Ministry of Municipal Affairs.

Measure 3 shall be included in the respective planning regulation issued by the Ministry of Municipal Affairs under the Municipality Law 29/1955, the Law of Planning for Cities, Towns Villages and Buildings 79 1966 on Planning and building regulations and the Jordan National Building Law 7/1993 as well as in the respective regulation issued by the Ministry of Water and Irrigation under the Water Authority Law 18/1988, i.e. the Wastewater Regulation 66/1994 and shall be enforced by the issuing authorities and their related entities.

V. Participatory Planning for Local Wastewater Management Solutions

Participatory planning (PP) is indispensable for measures involving wastewater collection, treatment and the reuse of treated wastewater. Yet not all relevant levels of Jordan's society are closely involved in wastewater management planning. Where implemented successfully it generates local ownership of the solution and hence sustainability. The latter is indispensable for cost-efficient and environmentally sound systems. In Jordan, where centralized treatment is not always the most cost-efficient option, decentralized solutions should be explored and where feasible and socially integrated they should be implemented. Their sustainability and effectiveness, however, will be out of the hands of the central government and will depend on the local and regional actors. At that a participatory planning will be one of the keys to successful implementation.

A. Historical and social bottlenecks

Due to a high increase in wastewater generation in Jordan in the 1990s WWTPs became overloaded and odor impacting communities was reported for several plants. Concern about odor and other environmental affects has persisted albeit replacements of many WWTPs by advanced systems. Therefore measures to involve the public in the planning process (Participatory Planning) are required for new wastewater projects in order to secure the acceptance and to mobilize local resources for their sustainability.

Participatory Planning in the area of wastewater management is yet not widely established in Jordan. Conventional wastewater projects, usually did not account for local stakeholder interests and many local communities have yet to adapt to an active role in planning processes. In order to overcome obstacles to successful implementation of new wastewater solutions, participatory planning measures require significant attention and resources. Experience has shown that the main barriers to changes in wastewater management in Jordan are the following:

Discrepancies between planning and reality: Even though willingness to pay for improved wastewater services, i.e. connection to sewer, was positively assessed in case studies on Jordan (e.g. Lienhoop et al. 2012), residents may be reluctant to pay for the planned wastewater infrastructure improvements even despite an established support scheme, e.g. microcredits. Affordability needs to be reconfirmed, by calculating the impacts of economic burdens from new wastewater systems on disposable household income. Willingness to pay for new wastewater projects will be established where the community will benefit from such a system and understands well how it will improve their lives.

Establish the reuse of treated wastewater: Jordan has established reuse in agricultural irrigation since the 1980s. The export market for food crops grown in Jordan with treated effluent had suffered from restrictions imposed by some of the importing countries of the Arabian Peninsula and Persian Gulf. Cultural and religious factors influence how people view the reuse of wastewater in agriculture. It is important to know, for instance, that the *Council of Leading Islamic Scholars in Saudi Arabia* (13th session, decision no. 64, dated 25/10/1398H) issued a Fatwa in 1978 concerning the use of treated wastewater. It concludes that treated wastewater can be used even for ritual washings and drinking, provided that it presents no health risks (Marschner et al. 2008: 44). In 2002 another Fatwa encouraged the reuse of treated wastewater as a method of cleaning and preservation (ibid.).

B. Structural bottlenecks

One major problem of stakeholder involvement in Jordan is the case of absentee landowners, who typically own large properties in the rural and suburban areas, but live in Amman or elsewhere. Their participation and support for participatory planning processes can be decisive when their consent is needed, e.g. for use of the land or for implementing a treatment facility close to their property.

C. CLUES Approach for participative planning approach for Wastewater Projects in Jordan

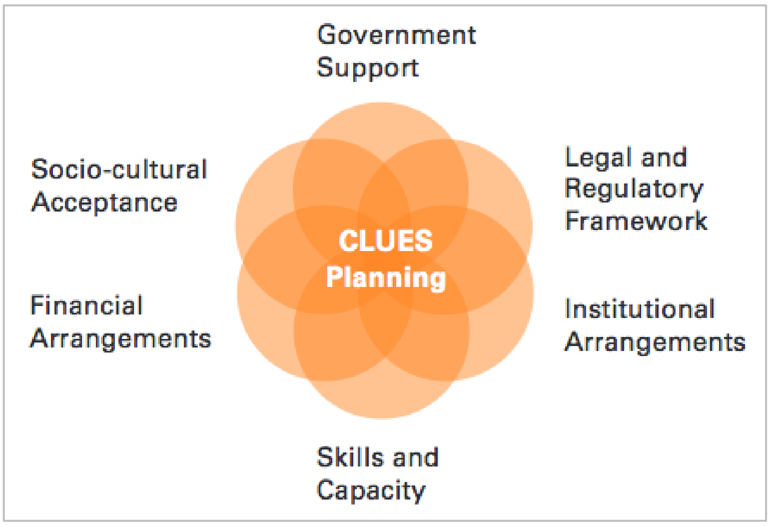
The Community-Led Urban Environmental Sanitation Planning (CLUES) (Lüthi et al. 2011)[2] is chosen here because its basic principles (self-determination of beneficiaries, wastewater as a resource, circular resource management, local solution to local problem) are in accordance with the approach to sustainable wastewater management in this Framework. The CLUES Approach is a further development of the “HCES Provisional Guideline for Decision-Makers” (Eawag 2005) and is based on four years of extensive field-level validation in seven sites around the world (Lüthi et al. 2011: 10).

[2] Community-Led Urban Environmental Sanitation Planning: CLUES, Complete Guidelines for Decision-Makers with 30 Tools, http://www.sswm.info/sites/default/files/reference_attachments/LUETHI%20et%20al%202011%20CLUES.pdf.

It is designed to enable urban communities and municipalities in to plan and implement cost effective environmental sanitation services that employ appropriate technologies suited to user needs. The structured 7-step process of the CLUES Approach and its toolbox are devised for the use of local authorities, donor agencies, planners and NGOs dealing with infrastructure planning and service delivery, as well as non-experts, local NGOs and community-based organizations that take part in such a planning process (Lüthi et al. 10).

The CLUES approach suggests an enabling environment, 7 planning steps, 3 cross-cutting tasks relevant throughout the entire planning process, and the enabling environment which is required for sustainable interventions (see Figure 4).

Figure 5: Defining Elements of the CLUES Approach: Enabling Environment



Source: Lüthi et al. 2011: 7

D. Enabling Environment for integrated wastewater management in Jordan

The CLUES approach specifically addresses the need for enabling environment in support of the actual process (Lüthi et al. 2011: 16). It enables local planners and citizens to take and implement decisions towards improving their current situation. In the case of wastewater management in Jordan, such an enabling environment may include the following items:

Element 1: A national wastewater policy that supports participatory planning processes and that embraces and clearly defines the necessary scales of wastewater management systems for Jordan, e.g. on-site, decentralized, semi-centralized, and centralized treatment.

Element 2: A national wastewater master plan that defines wastewater implementation projects for all scales, i.e. on-site, decentralized, semi-centralized, and centralized, including the allocation of financial funds for investment and O&M for new wastewater systems covering their complete life-time.

Element 3: Standards for effluent quality of treated wastewater that consider public and environmental health issues but allow for cost-efficient wastewater management for different reuse purposes as well as adequate parameters for monitoring the compliance to effluent quality requirements of the Ministry of Health, the Ministry of Environment, the Ministry of Water and Irrigation, and the Ministry of Agriculture.

Element 4: Arrangements for transferring competences and respective funds to local and/or regional authorities and communities to establish local units that are responsible for initiating and supervising the implementation of wastewater systems from the perspective of the benefitting community.

Element 5: Provision of funds (e.g. development bank loan or grant) that will enable national and local authorities and communities to prepare and induce wastewater projects.

Element 6: Provision of facilitators and trainers to implement training in order to develop the skills required on the part of municipal and regional representatives for implementing the CLUES approach in their local community towards improved wastewater management.

Participatory Planning requires the investment of time and financial resources. Facilitators of such processes often have to overcome opposition and involving a community where such planning processes are new, can be very time-consuming. However, where such participatory planning is implemented successfully, it will create local ownership and will contribute significantly to the success and the sustainability of the local wastewater solution

E. Measures

Measure 1: To establish an enabling environment for sustainable wastewater management planning in Jordan and the six elements mentioned above according to section V.D in this Framework.

Measure 2: To prescribe a Participatory Planning process for all wastewater infrastructure projects and community reuse projects in Jordan, funding for a Participatory Planning process for new wastewater infrastructure projects is required.

Measure 3: To involve media at a national scale to promote solution that combine wastewater, reuse and groundwater protection in Jordan.

F. Responsibilities to implement above Measures

Measures 1 is the responsibility of the National Implementation Committee for Effective Wastewater Management and should ultimately be implemented by the ministries and authorities participating in the National Committee for Effective Wastewater Management. The responsible authority for Element 1 and Element 2 is the Ministry of Water and Irrigation. The responsible authority for Element 3 is the Ministry of Health supported by the Ministry of Water and Irrigation, the Ministry of Environment and the Ministry of Agriculture. Element 4 shall be implemented by the Water Authority of Jordan. However, the redistributions of responsibilities and funds will need specific provisions and reallocation of funds on a national level and is thus subject to deliberation of the Government of Jordan. Element 5 and Element 6 shall be implemented by all agencies as well as national and international donor agencies, that implement wastewater projects in Jordan's communities.

Measure 2 shall be implemented by any national or international agency or private investor for all community wastewater infrastructure projects as well as for community reuse projects in Jordan.

Measure 3 shall be implemented by the Ministry of Water and Irrigation supported by the Ministry of Health, the Ministry of Environment, the Ministry of Agriculture as well as national and international donor agencies.

VI. Technology Selection Methodology and Procedure

A great many technological alternatives for wastewater treatment are available, ranging from high-tech treatment options to nature-based eco-technologies. Each technology requires specific approaches on planning, design and operation. In the absence of a technology certification procedure it is usually difficult to select the most appropriate technology from among the set of available technologies for a particular location and effluent quality. Factors, such as technology and site requirements and sustainability criteria, e.g. robustness and O&M requirements, are involved in the decision-making process.

Choosing the most appropriate technology might be difficult for decision makers in administrations, government and donor agencies, and engineering companies etc., as the extensive range of commercially available technologies challenges the personnel responsible for implementation that may not have comprehensive knowledge on comparing technology types and their individual features. This is particularly the case for technologies applied decentralized wastewater solutions.

A. Areas of Application of the Technology Selection Methodology

According to the definition of the different sizes of wastewater systems by the "National Implementation Committee for Effective Wastewater Systems in Jordan", the Helmholtz Center has developed a technology selection methodology for WWTPs with a capacity of up to 5,000 PE.

The technology selection approach as proposed in this study applies to domestic wastewater only. Wastewater other than domestic is not considered and its quality is assumed to be within the ranges indicated in Table 1 of section I (Introduction).

B. Technology Selection Methodology

1. Overview on Potential Treatment Technologies and Modules

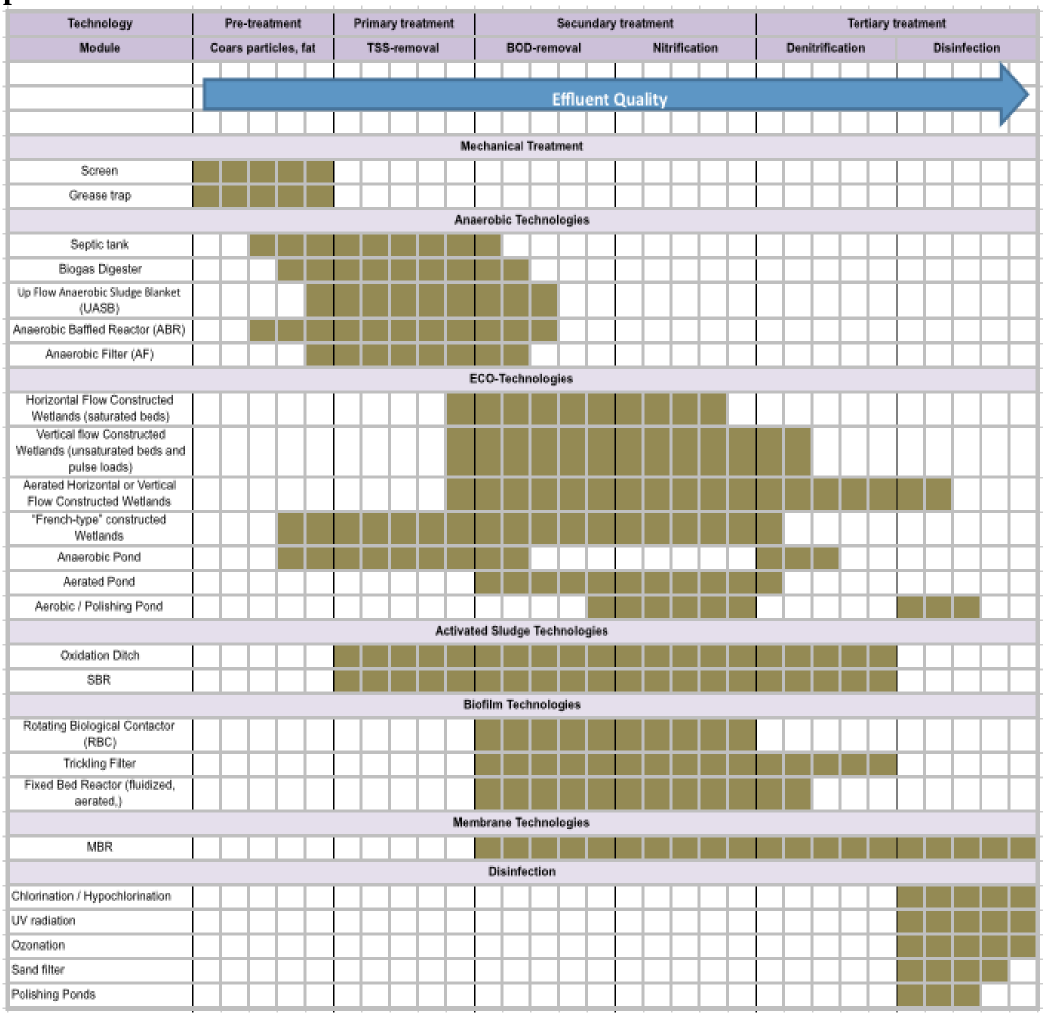
The following table gives an overview on existing technologies that are in use in semi- and decentralized wastewater management projects all over the world, have proven suitable and are potentially applicable under Jordanian conditions. Most of these technologies have so far been rarely used in semi- or decentralized wastewater management approaches in Jordan. Hence knowledge and experiences on the technologies' practical suitability and long term performances are very limited.

Generally, the constituents in wastewater are removed by physical (mechanical), chemical and biological means, which can be further broken down into distinct treatment processes or modules.

This methodology assumes that treatment modules that might be combined with each other into a so-called "treatment train" in order to meet the required Jordanian effluent standards.

Treatment modules may vary remarkably in terms of treatment performances (effluent quality). The following Table 4 indicates typical treatment performances of selected treatment modules. It clearly shows that only a few modules can treat wastewater to the maximum effluent standard on their own, while others need to be combined in order to meet the required effluent quality.

Table 4: Overview on Potential Treatment Technologies and Modules and their performances



Source: van Afferden et al. 2015, Study on Technology Selection for Decentralized Wastewater Treatment Applications in Jordan

While traditionally treatment processes are often linked to primary, secondary or tertiary treatment steps, DWWT modules are not necessarily limited to a certain position in a treatment train (primary, secondary, tertiary treatment), but may be combined with other modules where deemed suitable. In a decentralized approach, single modules might be considered sufficient if framework conditions permit (effluent requirements, however in most cases at least primary and secondary treatment are required. A detailed description of each module in the above table is provided in (van Afferden et al. (2015). Study on Technology Selection for Decentralized Wastewater Treatment Applications in Jordan).

2. Important Preliminary Remarks on the Treatment Selection Methodology

The selection of an appropriate treatment technology or a treatment train is a process involving a wide range of issues, such as technical, institutional, socio-economic, educational, and financial aspects.

Wastewater is a very complex and inhomogeneous media, which varies remarkably between locations, regions, and dischargers. Standard treatment solutions that ensure cost-efficiency and reuse specific effluent qualities regardless of local conditions do not exist. Treatment technologies cannot be selected from a shelf or a textbook, and every project requires a careful selection of treatment technologies and modules suitable to the specific treatment situation.

In order to support treatment selection process in Jordan a technology selection approach is recommended that structures and thus reduces the process' complexity along the following core elements. This study follows a three-phase approach:

- General list of appropriate treatment technologies/modules for Jordan: Definition and selection of treatment modules, that are suitable for application under Jordanian conditions, based on international and local experiences, that in principle are appropriate for the Jordanian wastewater context and that are currently available on the international market.
- Selection procedure for specific wastewater projects in Jordan: A selection procedure is provided that allows to find the most appropriate treatment technologies/modules for a specific wastewater project from the technologies of the general list.
- Recurrent revision of the general list of appropriate treatment technologies/modules for Jordan: The general list of appropriate treatment technologies/modules must be revised and adapted to new technology developments as well as to a more performance-based

approach latest in the year 2020 and subsequently every 5 years. This section will provide comprehensive guidance on how such a revision may be done.

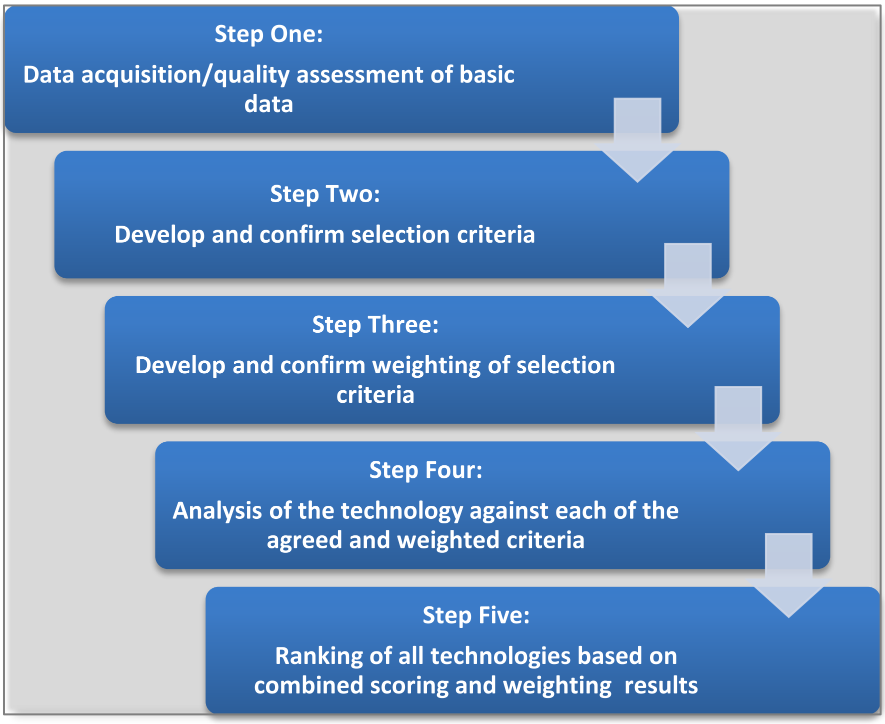
In the following the three-phase approach will be presented in more detail along its core elements:

- Data acquisition/quality assessment of basic data
- Establishment of selection criteria
- Application of selection criteria to technology
- Generation of list of pre-selected technologies

C. Multi-Criteria Analysis

The selection procedure is based on a multi-criteria decision matrix that uses a list of values in rows and columns to systematically identify, analyze, and rate technology options in order to tackle the trade off between different values (selection criteria) and to produce best options.

Figure 6: Multi-Criteria Analysis for wastewater treatment below 5,000 PE in Jordan



1. Step One: Data Acquisition and Quality of Basic Technical Data

Technology selection needs to be based on accurate input data. The following aspects need careful considerations when selecting a technology for any given wastewater infrastructure project.

The required information includes:

- Specific wastewater quality and quantity (actual and future, 10 years)
- Effluent requirements, including hygiene and public health requirements
- Peak flows and distribution of wastewater generation over 24 hours and 12 months
- Combined and separate sewer system in place or planned
- Site conditions (soil characteristics, available floor space/land, land slope, available road and power infrastructure, features of the groundwater catchment area)
- Identification of discharge points and/or local reuse options for treated effluent
- Reuse aspects (quantitative reuse requirements, quality requirements, etc.)

There is a severe risk of choosing inappropriate treatment technologies in consequence of incomplete data and/or data that does not meet the required level of accurateness or detailedness. This is often the case where necessary field and on-site investigations are not or cannot be carried out, or where the incoming wastewater changes in quality and/or quantity due to changed conditions (e.g. refugee influx, accelerated population growth, etc.)

In cases where the required data for selecting and designing a treatment process is insufficient, it is recommended to postpone the project until the required data is available. Alternatively, a very robust treatment technology shall be selected that is able to deal with a wide range of hydraulic and quality conditions.

2. Step Two: Develop and Confirm Selection Criteria

Technology selection for any wastewater project must be based on agreed, understandable and comprehensive criteria that can be evaluated and compared with each other as regards to their applicability and appropriateness for the particular wastewater project at hand and under Jordanian conditions.

For Jordan the following selection criteria best serve the current needs for developing wastewater management systems with a capacity up to 5,000 PE. However, these criteria might not be entirely fitting a given local wastewater situation and need to be adapted according to Step 1:

Table 5: Technology Selection Criteria for Jordan

Criterion	Description
Robustness	Capability of a WWTP to deal with shock loads, instable electricity supply, operating errors, technical failures, changing framework conditions and other potential impacts affecting treatment efficiency. Operational problems are more common in rural areas and insufficient or incomplete design data can partly be compensated with robustness against changing operational conditions. Robustness is particularly important where WWTPs are not permanently manned or O&M capability is limited. The lower the number of mechanical and electrical equipment (pumps, aerators, process control, etc.), the lower the potential for malfunction. The availability of spare parts (especially when imported) significantly affects the reliability of a WWTP.
Specific Total O&M Cost	Cost efficiency in terms of "best performance achieved for amount of money spent on O&M". Technologies are compared regarding their need for manpower, preventive maintenance, and energy consumption for meeting the targeted effluent standard. Cost efficiency assessment is usually done by comparing specific O&M costs of different treatment technologies in terms of JOD per m^3 wastewater treated or JOD per population equivalent (PE).
Specific Energy Cost for O&M	Energy consumption (or specific energy costs) of a WWTP contributes to the overall O&M costs and is included in the criterion "Specific Total O&M Cost". In Jordan, energy costs have reportedly developed dynamically during the past years and a steep increase in future can be expected. In anticipation of this development, energy consumption is crucial for technology selection and stated here as an additional selection criterion.
Capital Cost	The capital cost includes all expenses for the initial establishment of the WWTP (cost for design, engineering, and supervision of construction, construction cost, incl. materials, equipment, and labor, financing cost, and land acquisition cost). In developing and industrializing countries, capital (investment) costs are financed by soft-loan schemes provided by development banks or international donors. Such schemes, however, incentivize oversized high-tech solutions that produce high O&M costs and requirements, and are hardly sustainable.
Land Requirements	Space requirement ("footprint") of a WWTP is important, especially in Jordan where land may be limited and expensive. Highly mechanized and power consuming treatment plants (e.g. SBR) come with relatively small footprints, while nature-based solutions (e.g. constructed wetlands) may have a larger footprint.
O&M Requirements	Technologies requiring a stable power supply, skilled and experienced staff, complex process control, imported spare parts, etc. may not be suitable for local operators and their technical and managerial capabilities. In many cases there is a risk of treatment plants remaining idle following a short time of operation during which it has become evident that the operator is unable to perform, or when project budgets are spent. When introducing new technologies, comprehensive and time-consuming technical training will be required. For Jordan, simple technologies and processes that require simple O&M services are preferable.
Socio-Economics	Socio-economics include the willingness and affordability to pay for O&M costs through tariffs or taxes or via community commitment. Awareness of environmental protection and public health among the connected population is vital. The willingness to connect to public sewer is essential and is to be secured via meeting the needs and expectations of the targeted community.
Local Environmental Impact, Occupational Health & Safety (OHS) and Public Health	Environmental impacts are adverse effects caused by the release of hazardous substances to the environment. WWTPs may have an impact on the local environment during construction and operational life-time (odor, insects, rodents, noise, visual impacts, etc.), via discharge of treated effluent to a water body or via land application or due to failure or inadequate operation of the WWTP. Risks need to be assessed, i.e. impacts on groundwater quality through leaking sewage tanks or pipes, and a risk management to be included in the O&M scheme. WWTP plant operation comes with certain OHS risks, such as accidents, water borne diseases, exposure to chemicals. Especially for community-based O&M solutions, minimal

	exposure to OHS risks must be ensured. Closed systems (e.g. ABR, Constructed Wetlands, etc.) are given priority over open systems (e.g. aerated tanks or ponds) that bear the risk of direct contact with wastewater and the emission of aerosols. Closed systems can be located closer to settlements than open systems and also minimize potential for annoyance of dwellers in the proximity of the plant.
Sludge Generation and Quality	Sludge comprises organic and/or inorganic residue from septic tanks, sewer cleaning, lake or channel dredging, or wastewater treatment. Sludge may differ in characteristics and in degree of contamination. Generation and sludge treatment is a major concern given its potential adverse effects on the environment and public health. Hence, priority is given to technologies that either produce less or no sludge (anaerobic processes, constructed wetland) or stabilized sludge (e.g. oxidation ditch, French system constructed wetland).
Construction Requirements	The quality of construction directly influences the treatment performance and the potential of environmental hazards (such as groundwater pollution) through leaking tanks and pipes. Some technologies require special contractor skills for, e.g. the construction of gas-tight biogas digesters, the welding of Polyethylene liners, the set-up of Supervisory Control and Data Acquisition (SCADA) systems, electrical installations, and others.

D. Step Three: Develop and Confirm Weighting of Selection Criteria to Determine their Importance

Furthermore, a **weighting factor** (ranging from 1 to 10) for each selection criterion is applied, reflecting the current importance of each criterion in comparison to the other criteria. The definition of weighting factors for selection criteria is a process that is based on sector framework conditions and experiences of the persons involved in the definition process.

Application of the weighting factor is by multiplying it with each individual score. Based on a proposal from the Authors, both the scores as a result of applying the selection criteria as well as the weighting factors were discussed and agreed among the members of the aforementioned working group.

For a preliminary pre-selection of technologies suitable under Jordanian conditions, the following weighting factors were discussed and agreed upon in the "NICE Technology Selection Working Group":

Table 6: EXAMPLE of Weighting Factors for Technology Selection in Jordan

Criterion	Weighting
Robustness	10
Specific Total O&M Cost	8
Specific Energy Cost for O&M	8
Capital Cost	8
Land Requirements	4
O&M Requirements	7
Socio-Economics	4
Sludge Generation and Quality	2
Local Environmental Impact, Occupational Health & Safety (OHS) and Public Health	6
Construction Requirements	2

1. *Step Four: Analysis of the technology against each of the agreed and weighted criteria*

The assessment by selection criteria for every technology/module is performed by scores, ranging from zero (0) to five (5). The score (5) indicates best suitability under Jordanian conditions, while (0) stands for "no information available", or "not applicable". The number of scores is limited to 6 in order to keep this approach manageable.

Table 7: Scoring System for Technology / Module Assessment

Score	Definition
5	Most favorable / suitable performances in Jordan or under comparable conditions
4	Favorable
3	Less favorable, but applicable under certain conditions
2	Limited efficiency / limited applicability under Jordanian conditions
1	Not suitable under Jordanian conditions
0	No information available / not applicable

Scores can be added up so that each selection criterion can be compared and ranked with respect to every technology in question in order to identify most suitable technologies.

Table 8: EXAMPLE of Scoring a Rotating Biological Contactor (RBC) for Jordanian Technology Selection Criteria

Criterion	Performance of RBC	Scoring (0 - 5)
Robustness	• Spare parts must be imported • Sensitive to power cuts and hydraulic shock loads	3
Specific Total O&M Cost	• Spare parts must be imported • Electrical power supply must be permanent	3
Specific Energy Cost for O&M	• Permanent but moderate electric power consumption	4
Capital Cost	• Specific investment costs are rather high due to import and transportation	3
Land Requirements	• Relatively low	4
O&M Requirements	• Relatively low, but mechanical and electrical equipment needs regular attention	3
Socio-Economics	• Closed system with little annoyance for neighbors	4
Sludge Generation and Quality	• produces unstabilized sludge	2
Local Environmental Impact, Occupational Health & Safety (OHS) and Public Health	• Low impact	4
Construction Requirements	• Due to pre-fabricated systems, relatively low	4

Scores attributed to individual treatment modules should be based on past experiences, data from existing WWTPs in several countries including Jordan, published data and research. In a next step, the above scoring will be multiplied by their respective weighting factors and the weighted scores for each technology will be added up.

Table 9: EXAMPLE of Evaluation of Rotating Biological Contactor (RBC) from scoring for Jordanian Technology Selection Criteria

Criterion	Weighting (W) of Selection Criterion	Scoring (S) for Technology "RBC"	Result (W x S)
Robustness	10	3	30
Specific Total O&M Cost	8	3	24
Specific Energy Cost for O&M	8	4	32
Capital Cost	8	3	24
Land Requirements	4	4	16
O&M Requirements	7	3	21
Socio-Economics	4	4	16
Sludge Generation and Quality	6	2	12
Local Environmental Impact, Occupational Health & Safety (OHS) and Public Health	2	4	8
Construction Requirements	2	4	8
Total Weighted Score			**191**

The total score for the RBC system here is 191. This figure can be compared easily to each of the total score of other treatment systems of Table 4 (see page 40).

E. Measures

Measure 1: To revise the criteria and their current weighting for the technology selection of any new investment project.

Measure 2: To establish the developed technology selection procedure (multi-criteria analysis) as proposed by the technology selection study for public entities in Jordan.

Measure 3: To employ a neutral moderator to apply the technology selection procedure.

Measure 4: To establish a legal provision (umbrella) to establish a technology certification system that sets performance standards for wastewater treatment technologies in Jordan.

Measure 5: revise and amend the existing effluent standard JS 893-2006 based on the reuse standards for wastewater systems with a capacity below 5,000 PE as presented in section VII "Standards and Monitoring" of this Framework.

Measure 6: Revision of the current list of treatment technologies/modules and gradual introduction of performance-based technology selection approach by 2020.

F. Responsibilities to implement above Measures

The Ministry of Water and Irrigation, the Water Authority of Jordan, and any agency responsible for implementing a wastewater project in Jordan (international donors, urban developers (HUDC, GAM, and municipalities) are responsible for implementing Measure 1, Measure 2, and Measure 3.

The Ministry of Water and Irrigation and the Water Authority of Jordan together with the Jordan Chamber of Commerce are responsible for implementing Measure 4.

The Ministry of Water and Irrigation and the Water Authority of Jordan are responsible for implementing Measure 5 and supported by the Jordanian Institute for Standards and Metrology.

The Ministry of Water and Irrigation and the Water Authority of Jordan are responsible for implementing Measure 6.

VII. Regulatory specifications and programs for treated domestic wastewater from treatment plants with a capacity below 5,000 population equivalents

In Jordan, there exist no specific regulation for effluent standards and monitoring schemes for WWTPs with a capacity below 5,000 PE (henceforth: "decentralized wastewater treatment" (DWWT)). This poses a major investment obstacle in terms of economic and technical feasibility as such systems are currently subject to the regulations for large WWTPs (henceforth: centralized wastewater treatment ") while the inherent environmental risks of DWWT plants are by far smaller than those of centralized WWTPs. Therefore, a set of standards for DWWT plants based on internationally acknowledged environmental and health standards is needed in order to promote suburban and rural collection, treatment, and reuse of wastewater so as to realize economic payoffs, i.e. groundwater protection and fresh water substitution.

Many existing standards are based on those developed for urban centers and agglomerations in industrialized countries where conditions are very different from those applicable today in a suburban and rural context of developing and water scarce countries, and so are often inappropriate. Furthermore, many international standards can often not be complied with because associated technologies are too complex and expensive for the given socio-economic conditions. This is the case for the Jordanian Standards, which creates the need for rather sophisticated high-tech solutions as well as detailed and costly monitoring programs.

High-tech solutions are usually more complex and delicate and require experienced staff and complex process control. Such systems are not suitable for local operators and their technical and managerial capabilities. Furthermore, high-tech solutions also come with lower cost efficiency in terms of 'best performance achieved for amount of money spent on O&M'.

For any system of any size risks of contamination need to be controlled and protection of human health secured. While the latter is mandatory, there remains room for developing adequate monitoring programs for smaller systems in a suburban and rural context in order to ensure their efficiency and manageability.

Such efficiency gains are particularly important for treatment systems smaller than 5,000 PE. More feasible specifications for treated domestic wastewater which account for the particular situation of suburban and rural areas in Jordan are needed.

A. Objectives of the Chapter

- To provide a comprehensive overview on national and international water quality standards relevant for Jordan including contradictions among Jordanian standards.
- To provide a comprehensive overview on current monitoring schemes for wastewater treatment and reuse in Jordan including potential interferences and overlaps among different monitoring authorities.
- To develop reuse standards and monitoring schemes for DWWM systems in Jordan based on a thorough assessment of adequacy of current water use provisions for Jordan.
- To inquire into the need for conducting an Environmental Impact Assessment (EIA) for DWWM systems

B. Assessment of Jordanian Standard for Quality of Treated Wastewater

1. Jordanian Standard JS 893/2006 for reclaimed domestic wastewater

This current Jordanian Standard for reclaimed domestic wastewater JS 893-2006 relies on the guidelines that were developed for industrialized countries where water resources management focuses on the protection of surface water, which define the end-use based on the quality of water after being treated at a treatment plant.

Upon consideration of a better and integrated understanding of the reuse of domestic wastewater WHO has issued new guidelines in 2006 (see Table 10).

Table 10: Summary of WHO Guidelines for Reuse of 2006

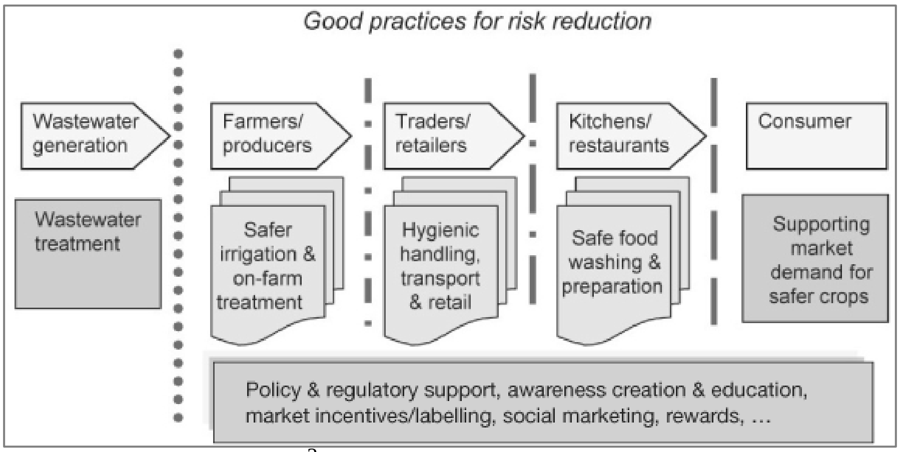
WHO Guidelines 2006
The health based targets apply a reference level of acceptable risk. Depending on the health-based target, E. Coli threshold value varies from 1,000 to 100,000 MPN/100 mL.
Takes into account all available bacterial reduction barriers (Multi-Barrier-Approach)
Provides an integrated approach combining risk assessment and management to control water-borne diseases (Stockholm Framework)
Can be adopted and applied to suit local socio- economic conditions.

The WHO guidelines of 2006 are based on the principle of bacterial reduction barriers from the source of wastewater until arrival of the agricultural product to the consumer's table (see Table 11).

Table 11: Multiple-Barrier Approach in the Reuse Food Chain

Control Measures	Pathogen reduction (log-unit)	Remarks
Wastewater Treatment	1-7	Depends on wastewater treatment process
Subsurface irrigation	6	Crops of which grow above soil
Drip Irrigation (low-growing crops)	2	Root crops and crops that grow just above but partially in contact with the soil, e.g. lettuce
Drip Irrigation (high-growing crops)	4	Crops of which the harvested parts are not in contact with the soil, e.g. tomato, bean

Figure 7: Multiple-Barrier Approach in the Reuse Food Chain



Source: Ilic et al. 2010[3]

2. Inconsistencies among Jordanian Standards

a) Jordanian Standard 286-2008 Water - Drinking Water

The maximum limit for Nitrate (NO3) in drinking water is 50 mg/L according to JS 286/2008 that also allows a maximum limit of 70 mg/L in the absence of a water supply with better quality and with the approval of the Ministry of Health. However, the reuse standard JS 893/2006 is much stricter as it requires a concentration of 30 mg/L for irrigation of cooked vegetables, parks, playgrounds and roadsides within cities.

b) Jordanian Standard 1145/2006 for the uses and disposal of treated sludge

JS 1145/2006 allows the reuse of sludge of quality classes I or II for improving soil properties or as organic fertilizer for agricultural purposes, while the Jordanian standard specification on fertilizers JS 962/2011 does not allow the use of sludge as fertilizer.

3. Proposed Effluent Standards for Treatment Plants servicing less than 5,000 PE

To facilitate reuse of treated wastewater in agriculture throughout the country effluent standards should be designed for the particular context of small and middle-sized treatment system. Since the direct contact of treated wastewater with humans is restricted and a

[3] Sanja Ilic, Pay Drechsel, Philip Amoah and Jeffrey T. LeJeune, 2010, Applying the Multiple-Barrier Approach for Microbial Risk Reduction in the Post-Harvest Sector of Wastewater-Irrigated Vegetables, , in: Wastewater Irrigation and Health Assessing and Mitigating Risk in Low-Income Countries Edited by Pay Drechsel, Christopher A. Scott,Liqa Raschid-Sally, Mark Redwood and Akiça Bahri, International Water Management Institute and International Development Research Centre, 2010, retrieved from http://www.idrc.ca/EN/Resources/Publications/openebooks/475-8/index.html

Multiple-Barrier Approach is integrated as a treatment step, the following effluent standards imply that in many cases no tertiary treatment step for denitrification and disinfection is required. Thus, the range of potential technologies becomes much broader and treatment solutions for suburban and rural areas more affordable and feasible, as they require basic O&M and moderate and affordable monitoring efforts (costs and technologies).

In general these standards would support the implementation of affordable treatment systems and would contribute to an improvement of the sanitation situation in Jordan.

The following effluent standard values are set for two size categories, i.e. design flow equivalent to the range of 51 to 500 PE (see Tables 12 and 13).

Table 12: Effluent values for wastewater treatment plants with a design flow equivalent to the range of 50 to 500 PE

Criterion	Abbreviation	Unit	*Maximum limit*				
			Open discharge	Infiltration trench	Subsurface irrigation	Drip irrigation	Open irrigation
Chemically consumed oxygen	COD	mg/L	150	150	150	150	150
Total suspended solids	TSS	mg/L	50	50	50	50	50
Total nitrogen	TN	mg/L	70	-	-	-	-
Nitrates	NO3-N	mg/L	60	-	-	-	-
Escherichia coli	E. Coli	MPN/100 mL	1000	-	-	1000	100
pH	pH	SU	6-9	6-9			

Open discharge	Discharge in nearby streams and valleys if the discharge area is fenced
Infiltration trench	Maximum daily load = 1 m^3 / 10 m^2, 365 days per year trees only
Subsurface irrigation	Maximum daily load 1 m^3 / 100 m^2 365 days a year no determination on the types of plants except root crops (potatoes, carrots, etc.)
Drip irrigation	Maximum daily load 1 m^3 / 100 m^2, 365 days a year fenced irrigation zone or with plastic mulch
Open irrigation	Maximum daily load 1 m^3 / 100 m^2, 365 days a year

Table 13: Effluent values for wastewater treatment plants with a design flow equivalent to the range of 501 to 5,000 PE

Criterion	Abbreviation	Unit	*Maximum Limit*			
			Open discharge	**Subsurface irrigation**	**Drip irrigation**	**Open irrigation**
Chemical Oxygen Demand	COD	mg/L	150	150	150	150
Total suspended solids	TSS	mg/L	60	50	50	50
Total nitrogen	TN	mg/L	70	70	70	70
Nitrates	NO3-N	mg/L	60	-	-	-
Escherichia coli	E. Coli	MPN/100 mL	1000	-	1000	100
pH	pH	SU	6-9			

Open discharge	Discharge in nearby streams and valleys if the discharge area is fenced
Infiltration trench	Maximum daily load = 1 m^3/ 10 m^2, 365 days per year trees only
Subsurface irrigation	Maximum daily load 1 m^3 / 100 m^2 , 365 days a year no determination on the types of plants except root crops (potatoes, carrots, etc.)
Drip irrigation	Maximum daily load 1 m^3 / 100 m^2 , 365 days a year fenced irrigation zone or with plastic mulch
Open irrigation	Maximum daily load 1 m^3 / 100 m^2 , 365 days a year

TSS parameter shall be revised and if possible eliminated within the next 5 to 10 years.

Treatment plants servicing more than 5 and less than 50 PE shall include a secondary biological treatment step and shall meet the effluent standards for systems ranging from 50 to 500 PE but are exempted for compliance with the TSS parameter for systems ranging from 50 to 500 PE.

4. *Monitoring Schemes for treatment plants servicing less than 500 PE*

a) Monitoring frequency for plants with a design flow servicing less than 500 PE

If the plant is within the borders of a groundwater protection zone 2, its owner shall monitor the plant once every six months. The environmental/health inspector shall be authorized to follow up the performance of the plant on a regular basis and at a rate of once every six months.

b) Monitoring frequency for plants servicing from 501 to 5,000 PE

The environmental/health inspector shall be authorized to follow up the performance of the plant on a regular basis, at a rate of once per every six months.

Effluent sampling analysis should be done in a accredited laboratory and shall be periodically conducted once every three months.

Once a technology certification system is established in Jordan, the monitoring frequency shall be further reduced.

5. Environmental Impact Assessment (EIA) for DWWT plants in Jordan

1. Treatment plants with a design flow servicing less than 50 PE and within city limits , require a preliminary EIA only.
2. Treatment plants with a design flow of less than 2,000 PE and outside city limits require a preliminary EIA only.
3. Treatment plants with a design flow servicing more than 2,000 PE per day require a comprehensive EIA.

6. Additional regulations for DWWT plants in Jordan to ensure public health & food security

a. To avoid mixing with other partial wastewater streams, treatment plants with a design capacity below 5,000 PE shall receive domestic wastewater only.

b. For the design of DWWT plants with a design flow greater than 50 PE private sector entities require official approval and licenses of MWI/WAJ.

c. The above standards apply to treatment plants that receive domestic wastewater from a sewage network and not to plants that receive wastewater from seepage tanks.

d. All operators of treatment plants with a design flow servicing more than 500 PE must undergo O&M training.

C. Measures

Measure 1: The above standards for effluent quality of WWTPs of Tables 12 and 13 shall be implemented.

Measure 2: A national agency of neutral status shall be established to supervise the compliance of implementation projects to the approved wastewater treatment plant design.

Measure 3: The management of treated wastewater for agricultural purposes, including the selection of crops, methods of irrigation, soil management and education of farmers about correct reuse practices, shall be improved.

Measure 4: To implement EIA schemes as stated in section B.5 in this Framework.

D. Responsibilities to implement above Measures

The Ministry of Water and Irrigation, the Water Authority of Jordan, the Jordan Valley Authority, the Ministry of Health, the Ministry of Environment and the Jordanian Standards and Metrology Organization are responsible for implementing Measure 1.

The Government of Jordan is responsible for implementing Measure 2.

The Ministry of Water and Irrigation, the Water Authority of Jordan, the Jordan Valley Authority, the Ministry of Health, the Ministry of Agriculture and international donor organizations are responsible for implementing Measure 3.

VIII. National Approach to Operation & Maintenance for Decentralized Wastewater Systems

A wastewater system that integrates centralized and decentralized sewage as complementary infrastructures represents a substantial transition in national water resources management. To secure the benefits of such a complementary wastewater infrastructure system (reuse, fresh water substitution, groundwater protection, improvement of sanitation) an integrated O&M strategy is needed to support all future investment programms.

Potential models of an integrated O&M approach for Jordan include various aspects of O&M for that need to be addressed, i.e. role and responsibilities of the public and the private sector and provisions for comprehensive quality control (professional qualifications, technical standards/requirements, approval and licensing procedure, contract management, tackling of institutional and technical bottlenecks, etc.).

For Jordan, a competitive market for O&M services for wastewater systems smaller than 5,000 PE shall be created in order to outsource these services to the private sector and to alleviate the pressure of the public sector. This market shall, however, be under public control of the Ministry of Water and Irrigation in order to ensure that quality and due diligence are maintained.

In contrast to centralized WWTPs, the permanent presence of technical personnel is usually not feasible nor required for smaller systems.

A. Main Objectives of the National Approach to O&M for Decentralized Wastewater Systems

The national approach to O&M for decentralized wastewater systems shall contribute to solving a fundamental problem, i.e. wastewater disposal in a safe and affordable manner. Proper O&M services are indispensable for the sustainability of wastewater infrastructure systems in order to avoid water losses as well as health and environmental risks. Furthermore, the cost-benefit relationship has a significant impact on achieving sustainability for infrastructure systems in general. Cost and the benefits of any wastewater system must be clear and projectable to its owner.

B. Institutional and technical bottlenecks for effective O&M for Decentralized Wastewater Systems

1. *Technical bottlenecks*

a) Urban distribution

Servicing a number of small-scale domestic treatment plants in remote areas efficiently differs from serving semi-centralized treatment clusters and their associated networks. O&M service gaps and overlaps due to managing scattered plants/clusters and networks simultaneously shall be avoided.

b) Differences in plant size and in treatment methods

Efficient and suitable O&M services need to account for different plant sizes and their respective O&M requirements in order to plan for labor and material quantities and qualities. To be able to adapt O&M schemes including schedules, material and labor to the requirements of different technologies and different reuse or disposal options of the treated effluent requires provision of different skill levels of specialized personnel and respective technical manuals.

2. *Institutional bottlenecks*

a) Standards, regulations and legislation

Effective and enforced legislation and standards for construction, O&M diligence, and reuse are required. One major bottleneck is company registration at the Ministry of Trade and Industry in Jordan as it follows different categories. The subcategory "maintenance" only exist under the category "contracting". Today, any company that wants to bid for O&M tenders should be registered under constructor/contracting while there are companies in Jordan, that are registered under "services" who could be competitive providers of O&M services. The subcategory "operation and maintenance for wastewater treatment" for both main categories is needed.

b) Building capacities for O&M of decentralized wastewater management systems in Jordan

Skilled operators and staff for O&M with the ability to select appropriate wastewater management systems and O&M schemes are essential to successful implementation and sustainable management of decentralized wastewater infrastructure.

c) Responsibilities and monitoring coordination

A clear definition of roles and responsibilities and strong coordination among institutions/authorities is indispensable to manage DWWM in Jordan effectively.

C. Types of O&M Providers

Decentralized wastewater management is not yet established and integrated in the wastewater sector in Jordan. However, several WWTPs are operated that could be classified as decentralized wastewater systems, indicating that there is a need for establishing small-scale solutions for suburban and rural areas.

O&M for decentralized wastewater management systems, i.e. systems that comprise one or more WWTPs with a design flow servicing less than 5,000 PE, shall be established through an agreement between the Ministry of Water and Irrigation/the Water Authority of Jordan, the responsible water utility, and private sector companies. The respective contract shall be stipulated between the treatment plant owner (community, municipality, water utility, or household) and one of the above mentioned potential O&M providers. However, O&M for decentralized wastewater systems shall be controlled and monitored by public regulator and should be based on an O&M certification scheme that covers education and training for O&M of decentralized wastewater management systems.

D. Contract Options for O&M Services for Decentralized Wastewater Management Systems

Among the different contract options (see Table 14), the Full O&M Coverage Service Contract (Management Contract) is the most appropriate for establishing decentralized wastewater management systems in Jordan. A preventive service contract or an inspection service contract are not appropriate for decentralized wastewater management systems in Jordan and shall not be applied.

Table 14: Potential Private Sector Participation (PSP) service contract models for decentralized wastewater management systems[4]

A: Full O&M Coverage Service Contract (Management Contract)	Provides 100% coverage of labor, consumables, parts and materials as well as emergency service, that means, comprehensive management services. Such contracts usually include comprehensive preventive maintenance for equipment and systems. Respective management capabilities and experiences need to be verified prior to assigning a company, as the contractor is completely responsible for operating and maintaining wastewater facilities and related installations. Potential contractors should be pre-qualified and the tender should be very specific about the requested O&M standards and routines. When repair and replacement coverage is part of the agreement, it is to the contractor's advantage to perform rigorous preventive maintenance on schedule, since they must replace the equipment, if it fails prematurely. In the short term (< 5 years), full-coverage contracts are usually the most comprehensive and expensive type of agreement. For longer contract periods, however, such a contract may be most cost-effective. Major advantages are ease of budgeting and risk bearing by the contractor.
B: Full-Labor Service Contract	A full-labor service contract covers 100% of the labor for repair, replacement, and maintenance of the core wastewater facilities and related installations. The facility owner is required to purchase all equipment and parts. Preventive maintenance and operation are usually part of the contract, while the actual installation of major treatment plant equipment such as pumps and control panels are typically. Risk and warranty issues usually preclude anyone but the manufacturer installing such equipment for the period specified in the contract. The cost of emergency repairs may be factored into the original contract in contrast to an agreement to responding to an incident within a defined period with the owner paying for the emergency labor separately. Some preventive maintenance services are often included in the agreement along with minor materials such as lubricants and other consumables. A full-labor service contract is the second most expensive arrangement in terms of short-term impact on the maintenance budget. Because they are responsible only for providing labor, the contractor's risk is significantly low when compared to a full-coverage contract.
C: Preventive Maintenance Service Contract	The preventive maintenance contract is generally purchased for a fixed fee and includes a number of scheduled and rigorous activities such as comprehensive inspections, equipment overhauls, and calibration of measurement devices and servicing of buildings. Generally the contractor provides the materials required for preventive maintenance as part of the contract. The contract may or may not include arrangements regarding emergency repairs. The main advantage of this contract type is that it is initially less expensive than both, the full-service and the full-labor contract, and it provides the owner with an agreement that focuses on quality preventive maintenance. However, budgeting and cost control regarding emergency repairs and replacements is more difficult because these activities are often done on a time-and-materials basis. With this type of contract the owner takes on most of the risk. Without a clear understanding of requirements, a facility owner could end up with a contract that provides either too much or too little service. In order to set up a preventive maintenance properly, a detailed understanding and experience of the preventive maintenance efforts is required.
D: Inspection Service Contract	An inspection contract, also referred to as a "fly-by" contract, is purchased by the facility owner for a fixed annual fee and includes a fixed number of periodic inspections of the wastewater facilities and related installations. However, inspection activities are much less rigorous than preventive maintenance. Simple tasks such as checking treatment plant outfalls on blockages, visual checks on fences, doors and buildings etc. are performed routinely, and for the most part inspection means looking to see if anything is broken or is about to break and reporting it to the facility owner. The contract may or may not require

[4] Based on Sullivan et al. 2010, Operation and Maintenance - A Guide to achieving operational efficiency, U.S. Department of Energy.

	that a limited number of materials, e.g. vehicles, tools, etc., to be provided by the contractor and it may or may not include an agreement regarding other services such as emergency repairs. In the short-term perspective, this is the least expensive type of contract. It may, however, also be the least effective. Low cost is the main advantage to this contract.

Table 15: Evaluation of potential PSP service contract models for decentralized wastewater management systems

Description	A: Full O&M coverage service & management contract	B: Full-labor Service Contract	C: Preventive Maintenance Service Contract	D: Inspection service Contract
Risk level for owner of treatment facility	Medium to Low	Medium	High	High
Risk level O&M service provider	High	Medium	Medium to low	Low
Main compensation basis	Performance	Staff input	Specified service items	Specified service items
Cost level	High	High	Moderate	Moderate
Cost coverage by WW charges (bankability)	To be assessed in detail	To be assessed in detail	Possible	Possible
Overall evaluation for Jordan	Most suitable	Suitable	Not suitable	Not suitable

E. Measures

Measure 1: Establishing an independent regulator to centrally control decentralized wastewater management systems in Jordan (O&M, qualification, training, licensing, public health, and financial management).

Measure 2: To establish a regulatory mechanism and proper contract management for involving the private sector in O&M for decentralized wastewater management systems. Contracts of contract type A (full O&M coverage service & management contract) shall be preferably established. Contract type B (full-labor Service Contract) shall be established wherever contract type A has been successfully implemented and been active for a minimum continuous period of 6 years.

Measure 3: To include beneficiaries in the mechanism for cost recovery of decentralized wastewater management systems.

Measure 4: A list of qualified potential O&M companies for DWWM systems shall be established and shall be revised every year. The list may include all qualified companies regardless of their registration ("commercial" and "industrial"). Tenders for "operation and maintenance of decentralized wastewater management systems" shall be open to these companies.

F. Responsibilities to Implement above Measures

The Government of Jordan and the Ministry of Water and Irrigation are responsible for implementing Measure 1.

The Ministry of Water and Irrigation together with the Water Authority of Jordan are responsible for implementing Measure 2 and Measure 3.

The Ministry of Water and Irrigation and the Ministry of Public Works and Housing are responsible for implementing Measure 4.

IX. General Measures

A. Role of the National Implementation Committee for Effective Decentralized Wastewater Management in Jordan

The National Implementation Committee for Effective Decentralized Wastewater in Jordan and the National Implementation Committee shall provide recommendations for improving implementation of DWWM to Management in Jordan shall supervise all wastewater projects in Jordan that involve wastewater treatment plants with a capacity ranging from 50 to 5,000 PE. Furthermore, every two years the implementation of the measures in this Framework shall be evaluated by the National Implementation Committee for Effective Decentralized Wastewater Management and recommendations for improving the implementation of DWWM shall be provided to the Minister of Water and Irrigation in the year following the evaluation year.

B. Human Capacity Development Measures for Decentralized Wastewater Management in Jordan

The following capacity development measures for implementing of the NICE-Framework for Decentralized Wastewater Management in Jordan shall be realized with the support of international donors and under the supervision of the National Implementation Committee for Effective Decentralized Wastewater Management.

Target group	Institution/ Target group	Measure/ Event	Remarks
Professionals	Water Authority, Housing and Urban Development Cooperation	Public (contract) management of operator models Technology selection/certification protocols Preparation of tender documents	Highly qualified lecturers are required
	NGOs, Municipalities		
	Urban planners (HUDC, MoMA, WAJ)	Integrated wastewater infrastructure planning GIS-based site and infrastructure development	
	Certified Laboratories (WAJ, RSS, etc.)	Monitoring routines	
	NICE-Steering Committee	New working group on “Capacity development” New working group “Permission and Licensing”	
Foreign Public Authorities	Regional exchange	Guided tours, workshops	Professional network must be initiated
General Public	Communities (teachers, students, social workers, citizens / neighborhoods…)	Participatory planning	Professional moderators must be involved

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