WASTEWATER MANAGEMENT AND REUSE: MOTIVATIONS, CHALLENGES AND OPPORTUNITIES IN DEVELOPING COUNTRIES

BY

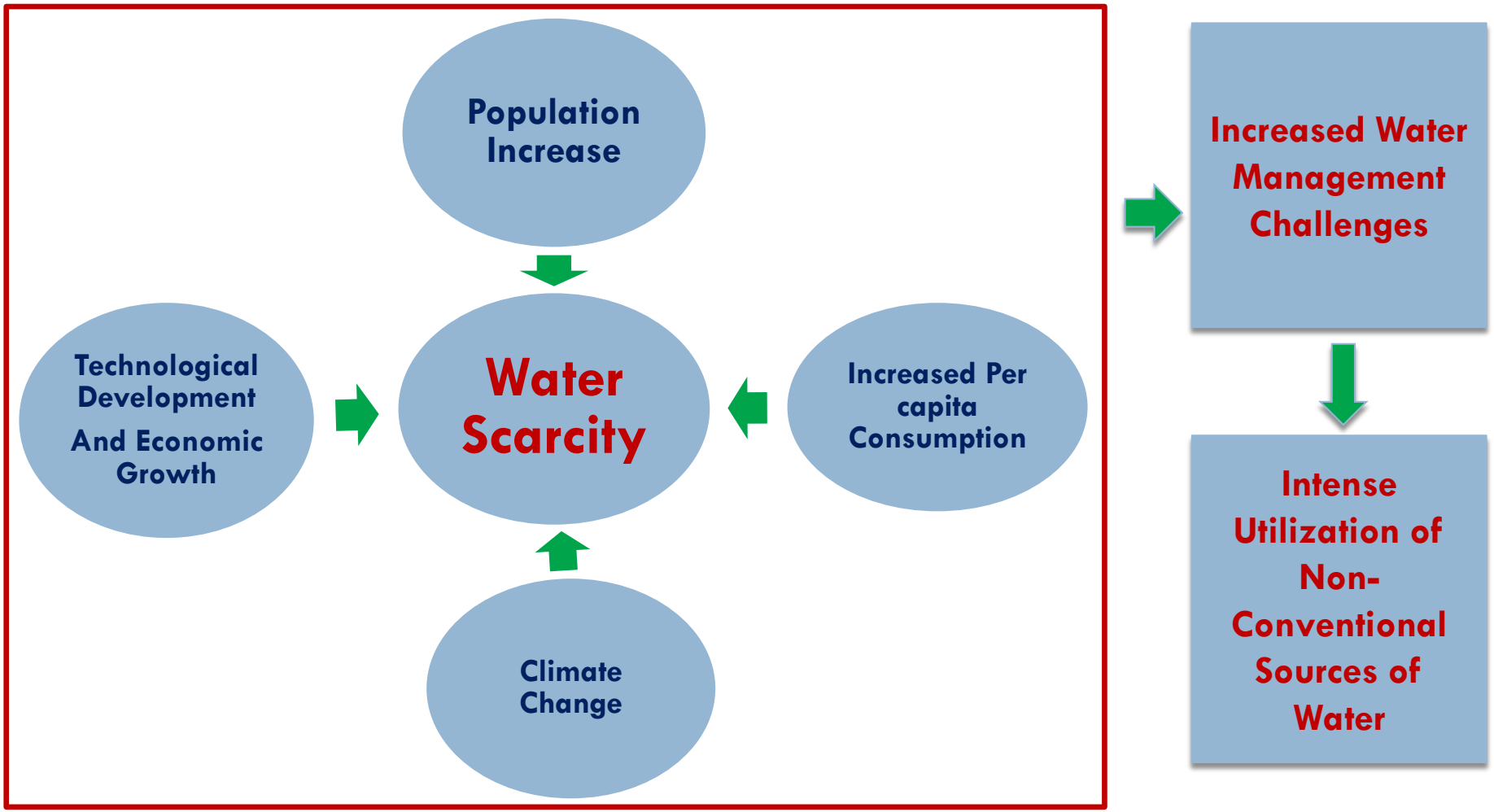
MAY A. MASSOUD

2nd Arab-American Frontiers of Science, Engineering, and Medicine Symposium, Muscat 13-15 December 2014

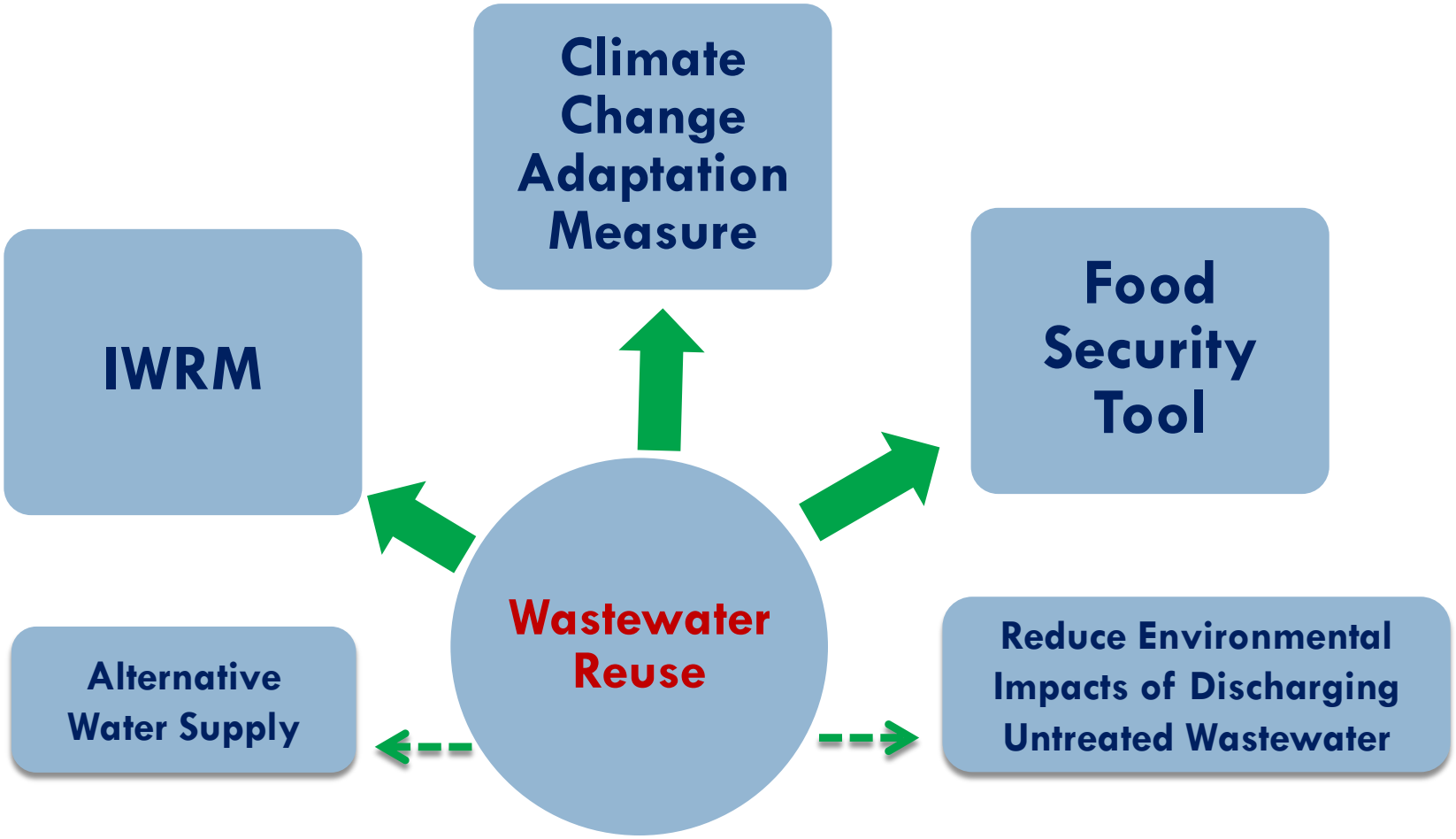
Outline

- Water Scarcity
- Wastewater Reuse Linkages
- Wastewater Reuse in most Arab Countries
- Challenges of Wastewater reuse
  - Technological
  - Economic
  - Political Factors
  - Regulatory and Institutional Aspects
  - Social Aspects and Risk Factors
- Planning for Wastewater Reuse

Water Scarcity



Wastewater Reuse Linkages



Wastewater Reuse in most Arab Countries

- **Generally, Tunisia (WRI*=12.7), Jordan (WRI=27.8) and the GCC countries are the leaders in the wastewater reclamation and reuse**

Country Ref: adapted from 4, 5	Type of Reuse
Egypt	Agriculture (direct forage and trees, indirect vegetables)
Jordan	Agriculture (direct forage and trees, indirect vegetables), Grey water reuse
Lebanon	Agriculture (limited)
Morocco	Research and Pilot
West bank	Agriculture and Grey Water reuse
Syria	Agriculture – all crops
Tunisia	Irrigation of green areas, Agriculture, Wetlands
Yemen	Agriculture – all crops
UAE	Green space irrigation

* *Wastewater Reuse Index* (*WRI*) which quantifies the total amount of wastewater being reused as percentage of the total generation of wastewater (MWI, 1991; ONAS, 2001; Abu Madi and Alsaed, 2009)

Wastewater Reuse in most Arab Countries

Country Ref: 1-13	Degree of Treatment	Treatment Techniques Employed
Egypt	P, S	AS, OD, TF, and WSP
Jordan	S	AS, TF, WSP, EA, and anaerobic sludge digesters
Morocco	P, S, T	Natural lagoons, AL, TF, AS, and WSP
Lebanon	P, S	Settling tanks and AS
Syria	S	AS, Wet Land, Oxidation ponds, and AL
Tunisia	S	AS, OD, WSP, AL, and TF
Yemen	S	WSP, settling/Imhoff tanks (predominant), AS, TF, and EA
UAE	S, T	AS and SF
Kuwait	T, A	AS, OD, SF, DF, UF, and RO
Algeria	S	AS, WSP, AL, SF, reed bed sewage treatment, and garden filter
Bahrain	S,T	AS, SF, RBC, AL
Oman	S, T	AS, WSP, RBC
KSA	S, T	AS, WSP, TF
Sudan	S	WSP, AS

P: Primary, S: Secondary, T: Tertiary, A: Advanced

AL: Aerated Lagoons, WSP: Waste Stabilization Ponds, TF: Trickling Filters, SF: Sand Filtration, AS: Activated Sludge, OD: Oxidation Ditches, UF: Ultra Filtration, RO: Reverse Osmosis, DF: Disc Filtration, RBC: Rotating Biological Contactors, EA: Extended Aeration

Wastewater Reuse in most Arab Countries

Categories of Arab Countries According to Reuse Standards Status (ref: 5, 7, 13, 14)

Category 1	**Includes Arab countries that adopt low-risk WHO and FAO based on low technology and low cost, such as Bahrain, Jordan, and Morocco have adopted fully or partially WHO and FAO guidelines (Loutfy 2010; WHO 2006; WHO 2005; & Choukr-Allah 2010).**
Category 2	**Includes Arab countries that adopt stringent reuse guidelines based on high technology and high cost similar to California reuse quality standards, for example Kuwait, Oman, KSA, and UAE (Choukr-Allah 2010 & WHO 2005).**
Category 3	**Includes Arab countries that have their own country specific national public health laws to regulate reuse practices, such as Egypt and Syria.**
Category 4	**Includes Arab countries that have no specific standards for wastewater reuse, such as Lebanon, Palestine, Iraq, and Yemen.**

Wastewater Reuse in most Arab Countries

Country Ref: adapted from 4	Safety Control	Risk Management
Egypt	Monitoring is limited and no corrective measures are known	No risk management system
Jordan	The Food and Drug Administration is responsible for sampling, analysis and evaluation under the Crop Monitoring Program for Fresh Fruits and Vegetables Produced in the Jordan Valley	Many organizations have a stake in the quality control of wastewater effluent with overlapping responsibilities
Lebanon	No monitoring system or safety control system due to the lack of WWTP	No risk management system
Morocco	There is a general quality control of water resources but nothing specific for wastewater reuse	No risk management system
Syria	Irrigation water is monitored but no corrective measures are taken in case of pollution	No risk management system
Tunisia	WWTP effluent is monitored but enforcement and corrective measures are limited	No risk management system
Yemen	Some quality parameters for WWTP effluent are monitored but due to the lack of funds corrective measures are impossible	No risk management system
UAE	Abu Dhabi frequently monitors the effluent quality as water is distributed for green space irrigation purposes. No information on the other Emirates	No information available about risk management systems

Wastewater Reuse in most Arab Countries

- Unfortunately, in many countries that are already using or start using treated wastewater, the monitoring and evaluation programs are not well developed
- Ignoring monitoring evaluation parameters or performing monitoring not regularly and properly could result in serious negative impacts on health, water quality and environmental and ecological sustainability

Wastewater Reuse in most Arab Countries

Income Level of Arab Countries

High	**Bahrain, KSA, UAE, Oman, Kuwait, and Qatar**
Upper Middle	**Algeria, Jordan, Iraq, Tunisia, Libya, and Lebanon**
Lower Middle	**Egypt, Syria, Morocco, Palestine, Yemen, Sudan, Mauritania, and Djibouti**
Low	**Somalia, Comoros**

Source: World Bank. (2013). "Countries and Economies". Retrieved from: http://data.worldbank.org/country/

Challenges of Wastewater Reuse

Technological:

- The problems related to wastewater treatment and reuse cannot be solved simply by constructing treatment plants
- These plants must also be operational and effective
- The uncritical adoption of international criteria for design of wastewater treatment plants and ignorance of the local conditions could result in wasted capital

Challenges of Wastewater Reuse

Technological:

- **Wastewater treatment plants in many Arab counties do not operate satisfactorily**
- **Might be attributed to the lack of adequately trained staff with the technical skills to operate these plants, as well as the lack of an adequate budget for plant maintenance and operation**


18 1:23


S6
18 1:23


18 1:25

Challenges of Wastewater Reuse

Economic

- **Often, the high cost of wastewater treatment and management is a major impediment towards implementing such projects**
- **The additional treatment of wastewater beyond secondary treatment for reuse and the installation of reclaimed water distribution systems can be costly**
- **The economic considerations are necessary because, when other sources of water are available at a cheaper price, it may not be worthwhile to reuse wastewater**

Challenges of Wastewater Reuse

Political Factors and Regulatory and Institutional Aspects

- The lack of political commitment and of a national policy and/or strategy to support wastewater treatment and reuse are main constraints in most Arab countries
- The most advanced technology should be supported by the appropriate institutions and enforced legislation to ensure maximum efficiency

Challenges of Wastewater Reuse

Social Aspects and Risk Factors

- The reuse of wastewater, whether direct or indirect, raises public concern as a result of the overall risk perception
- In general, public health concern is the major issue in any type of reuse of wastewater, be it for irrigation or non-irrigation utilization, especially *long term impact of reuse practices*
- Human health risks from wastewater irrigation include farmers' and consumers' exposure to pathogens including helminth infections, and secondly, organic and inorganic trace elements

Challenges of Wastewater Reuse

Social Aspects and Risk Factors

- Although water reuse has been practiced indirectly for decades through the existing water cycle of abstractions and discharges to rivers, the reuse of water does carry potential risks that need to be addressed
- For instance, pathogens and biological agents that can potentially cause disease and illness may be present in any wastewater that is discharged to a water course and is subsequently reused for water supply


17 22:17

Challenges of Wastewater Reuse

Social Aspects and Risk Factors

- Despite the limitations of epidemiological investigations, the reuse of wastewater has not been implicated as the cause of major infectious disease outbreaks
- Emerging contaminants, in particular endocrine disruptors and pharmaceutically active chemicals, are becoming a concern for environment protection and health for indirect potable reuse schemes

Challenges of Wastewater Reuse

Social Aspects and Risk Factors

- Adverse impacts on environment include alteration of land use, impacts on wetlands and ecosystems, effects on soils, plants and aquifers
  - Unregulated irrigation with wastewater may lead to problems such as deterioration in soil structure which results in poor infiltration, soil salinization, and phytotoxicity
  - Potential environmental impacts from the reuse of wastewater in agriculture may also include groundwater and surface water contamination as well as degradation to natural habitat and ecosystems

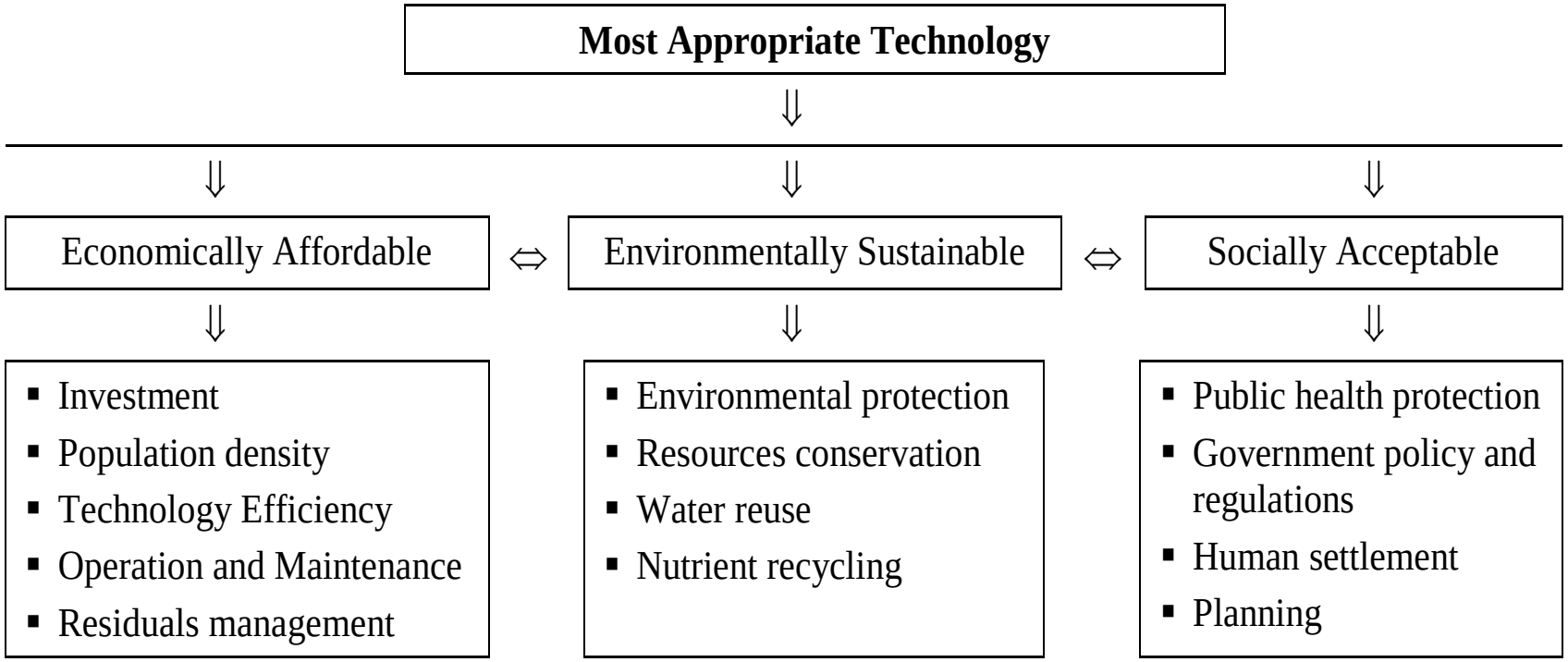
Planning for Wastewater Reuse

- The formulation of realistic, economically feasible, safe and socially acceptable set of standards and regulations is very essential
- Codes of practices for sustainable use are also crucial
- Policies accompanied by national strategies for wastewater reuse are preconditions to success
- Many different stakeholders are involved and it is very crucial to allocate responsibilities in both treatment and reuse stages
- Existing water charges must be changed so that they reflect scarcities and wastewater management fees

Planning for Wastewater Reuse

- While there are many impediments and challenges towards wastewater reuse, these can be overcome by comprehensive planning, risk assessment and policy implementation
- Establishment of wastewater infrastructure should include a systematic evaluation of all options, beginning with consideration of on-site systems and simple technologies and finally, the centralized treatment option

Planning for Wastewater Reuse



Planning for Wastewater Reuse

- Technologies available are many and well known, but any choice should rely on those not entailing excessive costs and providing the best environmental practice and option
- Also, reuse site must be located as close as possible to the wastewater treatment and storage facilities

Planning for Wastewater Reuse

- The choice of an adequate technology should be based on an integrated assessment of the local technical, environmental and social aspects
- Replication of successful projects is beneficial but the system should be adjusted to meet the local conditions
- A comprehensive and long term strategy that requires extensive planning and implementation phases is vital for sustainable wastewater management and reuse

Planning for Wastewater Reuse

- There are a number of technologies for treating wastewater for reuse
- The technologies chosen depend on the intended use
- During the last decades, membrane treatment has been approved as the best available technology for the production of high quality recycled water for indirect potable
- Among the membrane processes used for wastewater treatment, membrane bioreactor (MBR) technology is advancing the most rapidly worldwide

Planning for Wastewater Reuse

- Monitoring (process control and compliance) and evaluation of wastewater use programs and projects is a very critical issue, hence, both are the fundamental bases for setting the proper wastewater use and management strategies
- Equally important, monitoring programs must provide reliable and timely data

Planning for Wastewater Reuse

- More participatory approaches: To achieve general acceptance of re-use schemes, it is of fundamental importance to have active public involvement from the planning phase through the full implementation process
- Health education targeting policy makers, consumers/farmers/end users, local authorities, NGOs, Media can play an important role

Planning for Wastewater Reuse

- Differentiation between developed and developing countries, rural and urban as well as centralized or decentralized is required
- Monitoring and evaluation to guarantee quality is essential to protect public health
- Reshaping our approaches of development, especially in terms of holistic management of water, wastewater and energy is equally important

Planning for Wastewater Reuse

- The international Organization for Standardization (ISO) established a technical committee for water reuse whose scope is the standardization of water reuse of any kind and for any purpose
- This standardization has potential implications for Arab Countries as it might affect export opportunities and tourism
- It is essential to take an active part in the discussions and formulation of waste reuse standards to reflect the challenges that are mentioned earlier

References

1. *Abdalla, K. and and Gaid, A. (2013). "Upgrading of the Existing Wastewater Treatment Plants in Egypt Using Discfilter". Civil and Environmental Research, Vol.3, No.13, 2013.*
2. *Abdel Wahaab, R., Omar, M. (2013). "Wastewater Reuse in Egypt: Opportunities and Challenges".*
3. *Al-Anzi1, B., Abusam, A. and Shahalam, A. (2011). "Wastewater Reuse in Kuwait and Its Impact on Amounts of Pollutants Discharged into the Sea". Journal of Environmental and Analytical Toxicology 2011, S:3.*
4. *Arab Countries Water Utility Association (ACWUA). (2010). "Wastewater Reuse in Arab Countries".*
5. *Choukr-Allah, R. (2010). "Chapter 7: Wastewater Treatment and Reuse". "Arab Environment: Water -Sustainable Management of a Scarce Resource", Arab Forum for Environment and Development.*
6. *Hammouche, H. (2011). Experts Consultation on Wastewater Management in The Arab World: Algeria Report Country". Department of purification and the environment protection, Ministry for the Water Resources, Democratic and Popular Republic of Algeria.*
7. *Loutfy, N. (2010). "Reuse of Wastewater in Mediterranean Region, Egyptian Experience".*
8. *Makhokh, M. and Bourziza, H. (2011). "Country Report for the Expert Consultation on Wastewater Management: Morocco". SEEE and ONEP, Kingdom of Morocco in Expert Consultation Wastewater Management in the Arab World 22-24 May 2011, Dubai-UAE.*
9. *Ministry of Energy and Water (MoEW) –Lebanon. (2012). "National Strategy for the wastewater Sector". Lebanese Government, Resolution no. 35, Date 17/10/2012.*
10. *Ulimat, A. (2012). "Wastewater Production, Treatment, and Use in Jordan". Ministry of Water & Irrigation, Water Authority of Jordan in Second Regional Workshop 'Safe Use of Wastewater in Agriculture', 16-18 May 2012, New Delhi, India.*
11. *UN-Water Activity Information System (UNW-AIS). (2008). "Syria National Report on: The Actual Statues of Wastewater and Reuse for Agriculture in Syria".*
12. *World Health Organization (WHO). (2005). "A Regional Overview of Wastewater Management and Reuse in the Eastern Mediterranean Region". World Health Organization, Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health Activities (CEHA).*
13. *World Health Organization (WHO). (2005). "A Regional Overview of Wastewater Management and Reuse in the Eastern Mediterranean Region". World Health Organization, Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health Activities (CEHA).*
14. *World Health Organization (WHO). (2006). "A Compendium of Standards for Wastewater Reuse in the Eastern Mediterranean Region". WHO, Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health Activities (CEHA).*

Thank You for Your Attention