The Role of Treated Wastewater Reuse in Water Sustainability in GCC Countries

Dr. Mohamed A. Dawoud
Water Resources Advisor
Environment Agency – Abu Dhabi, UAE

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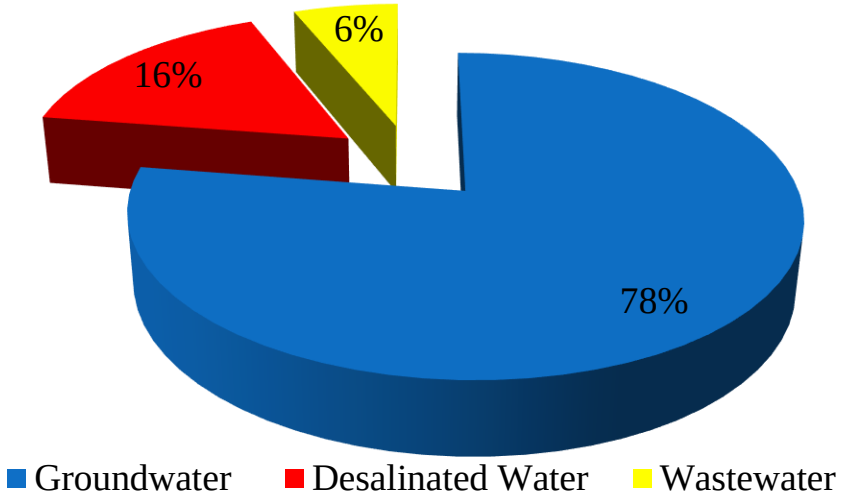
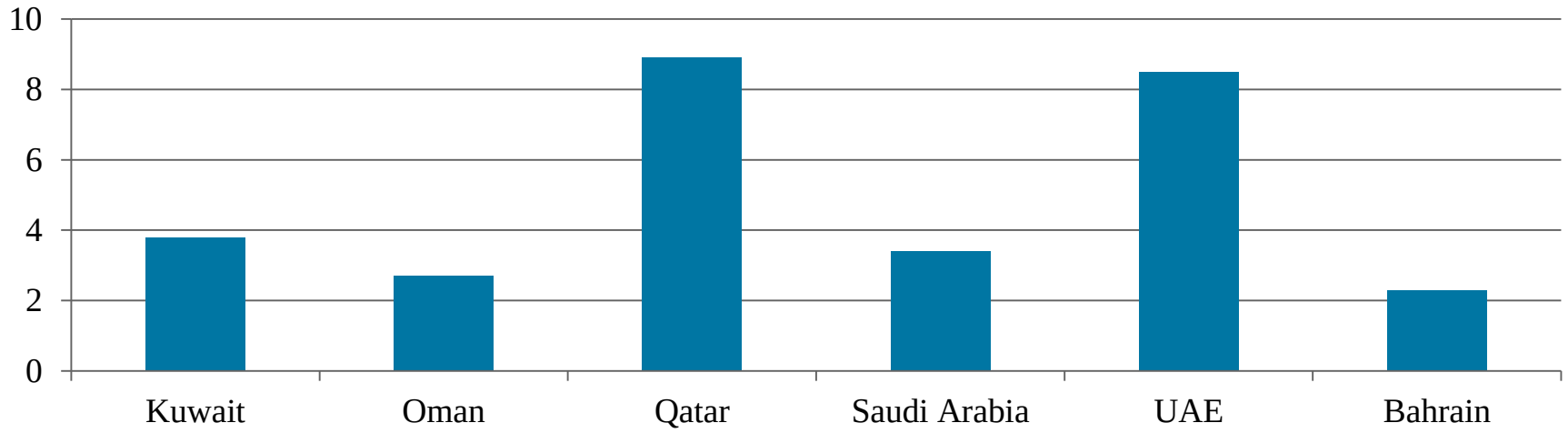
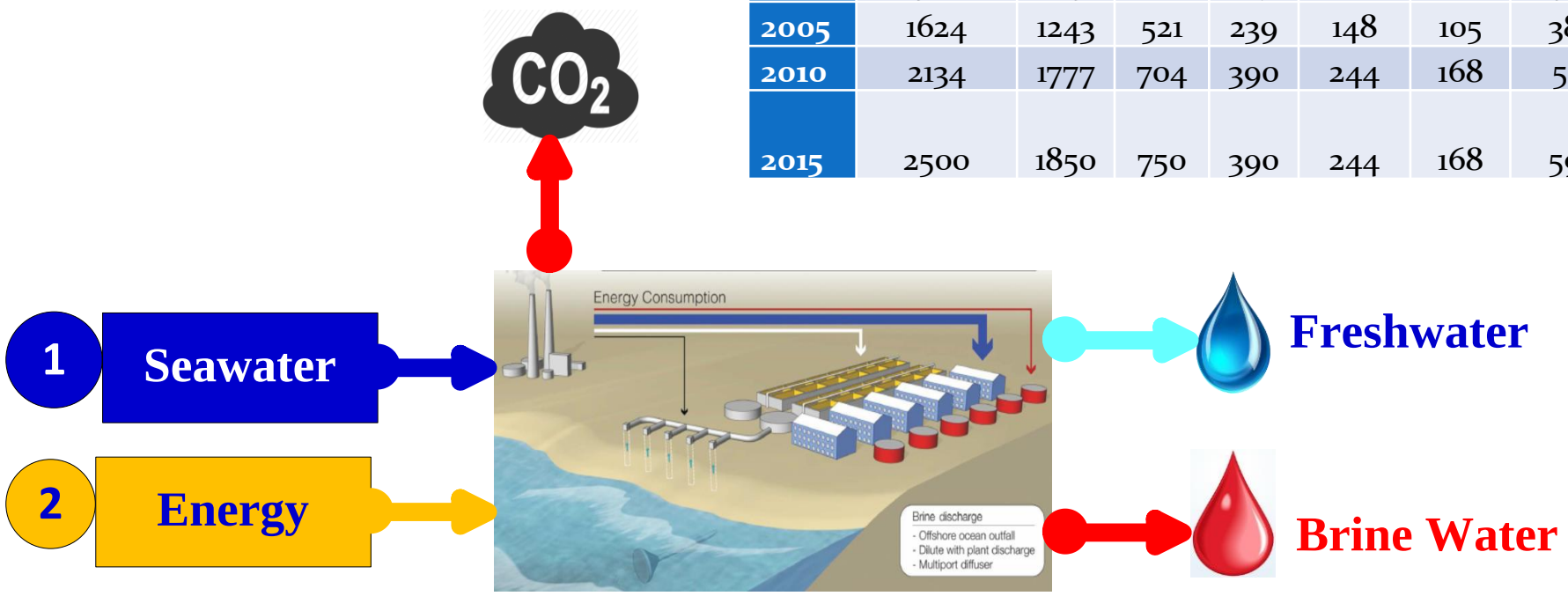
Introduction





Desalination inputs, outputs and environmental impacts

Year	Saudi Arabia	UAE	Kuwait	Qatar	Bahrain	Oman	Total
2000	1500	773	476	189	141	71	3151
2005	1624	1243	521	239	148	105	3879
2010	2134	1777	704	390	244	168	5417
2015	2500	1850	750	390	244	168	5902



Input

- Damage to marine ecosystems from desalination intakes
- Non-renewable energy sources

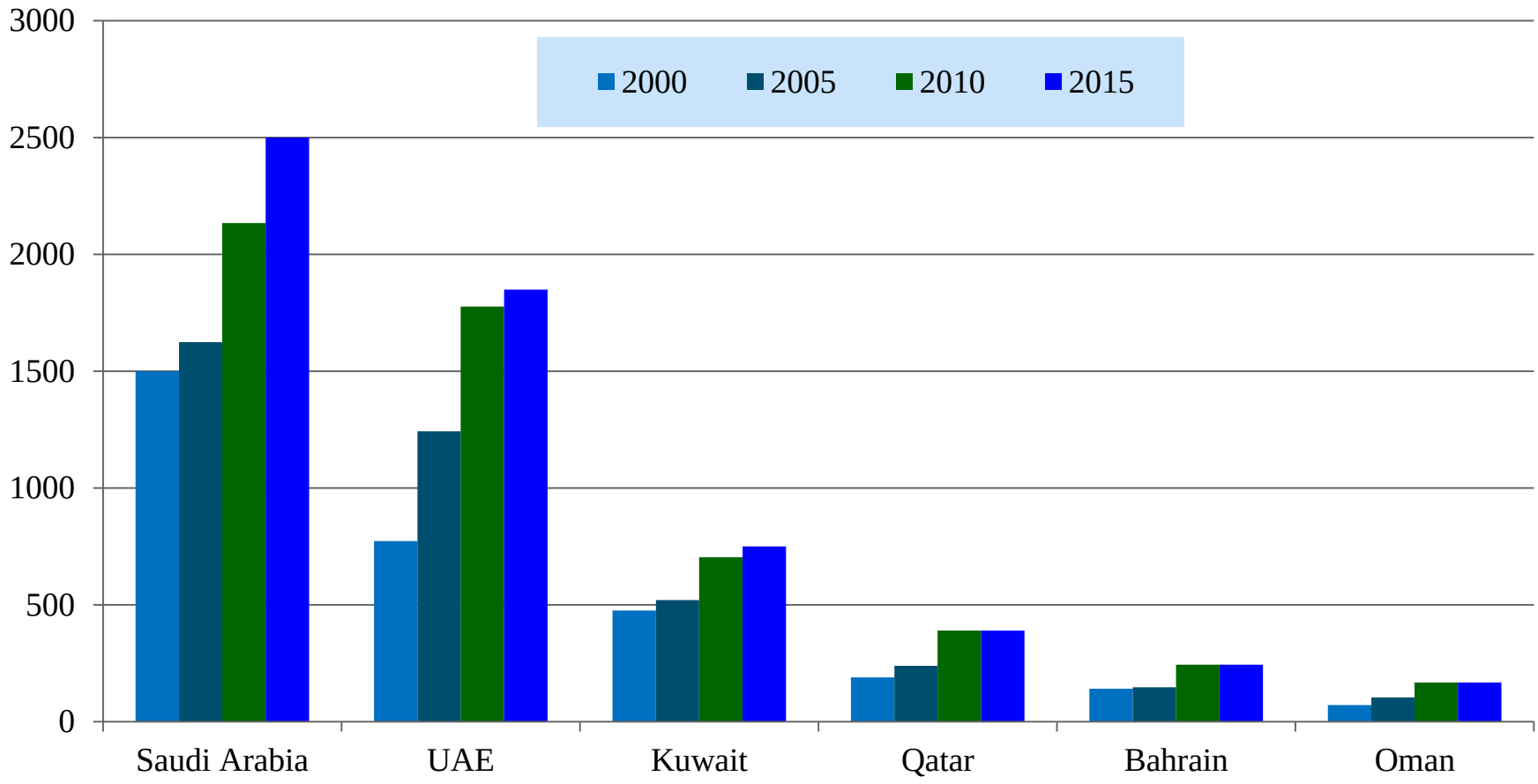
Process

- Process inefficiencies

Output

- Greenhouse gases emission and potential air pollutions
- Thermal, chemical and saline pollution which threat the marine life.

Development in desalination production in GCC countries (2000-2015)



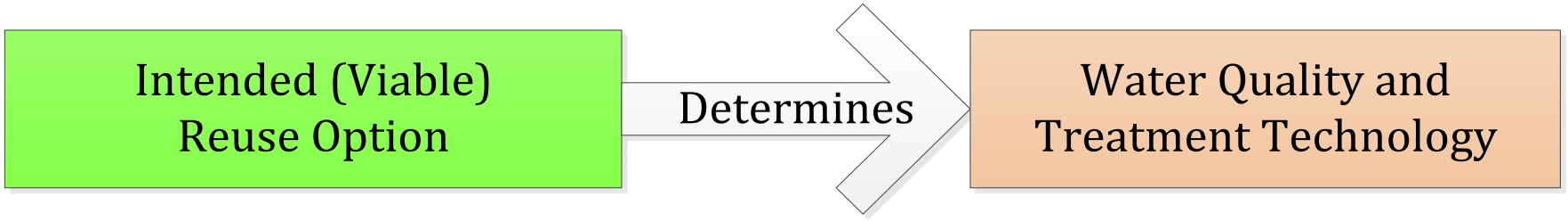
Treated wastewater production and use in GCC countries.

Country	TSE Production (Mcm)			Reused	Discharge to Environment
	2010	2015	Future Planed Capacity (2020)	2015	2015
Bahrain	81	102	150	31	72
Kuwait	254	290	420	189	102
Oman	39	84	125	67	17
Qatar	104	160	230	64	96
Saudi Arabia	712	812	1,200	487	325
UAE	352	587	900	264	323
Total	1,542	2,034	3,025	1,101	933

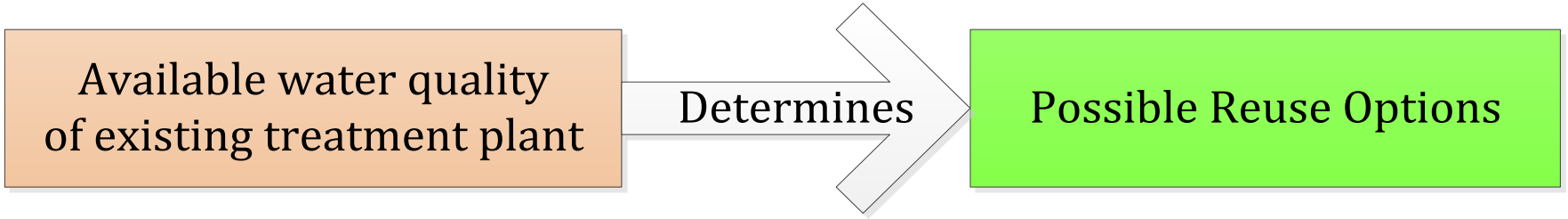
Sustainable Option for Reusing TSE in GCC Countries

Two approaches for planning and reusing treated wastewater

A) Future Oriented and Flexible



B) Status Oriented and Restrictive

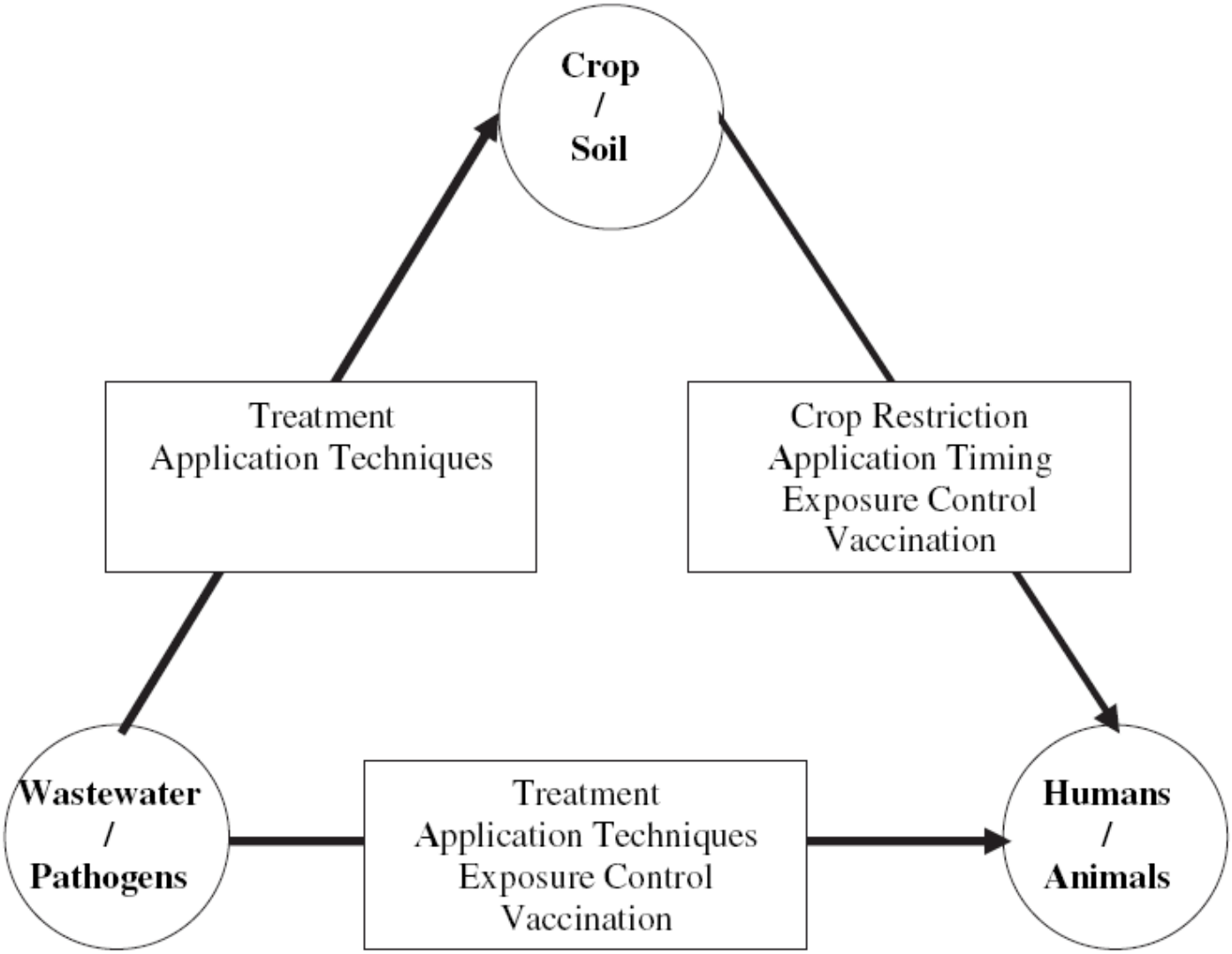


Reuse in Agriculture and Food Production

Selection criteria for irrigation method with treated wastewater

Under normal conditions, the following factors should be considred during the selction of any irrigation method:	Other factors that should be carefully considered for the irrigation with treated wastewater (in addition to normal conditions factors)
• Water supply conditions • Climate Conditions • Soil Characteristics • Cost of Irrigation Method • Type of Crops • System operation and management	• Wastewater Quality • Health Risk (Farm Workers) • Protection of Soil and Groundwater • Salinity and Toxicity Hazards • O&M cost • Water application

Risk Management for Wastewater Reuse in Agriculture



Steps in Agricultural WW Reuse Management: *Crop Restriction*

- Water of poorer quality can be used to irrigate:
  - *Non-vegetable crops such as cotton*
  - *Crops that will be cooked before consumption (e.g. potatoes)*
- Crop restriction may protect the health of consumers but **not farm workers and their families**.
- Crop restriction is not an adequate single control measure
- It should be considered within an integrated system of control
- In Chile the use of crop restriction when implemented with a general hygiene education program significantly reduced the transmission of cholera from the consumption of raw vegetables
- It has also been used effectively in Mexico and Peru

Steps in Agricultural WW Reuse Management: Irrigation Techniques

- Aerosols from spray/sprinkler irrigation have high potential to spread contamination on crop surfaces and affect nearby communities.
- Where WW spray/sprinkler irrigation is used, buffer zones (e.g. 50–100m from houses/roads) are recommended to prevent health risks to local communities
- Farm workers/families are at highest risk when flood or furrow irrigation techniques are used
  - *Especially when protective clothing is not worn and earth is moved by hand.*
- Localized irrigation techniques (e.g. bubbler, drip, trickle irrigators) offer farm workers good health protection because WW is applied directly to the plants
  - *Can be problematical if WW has suspended solids that clogs water emitters.*
- Drip irrigation also improves crop yields and reduces water use.
- Cessation of irrigation for 1–2 weeks prior to harvest can be effective in reducing crop contamination.
- Many vegetables need watering nearly until harvest to increase market value
  - *This option may be possible with some fodder crops that do not have to be harvested at the peak of their freshness.*

Reuse in Industrial Purposes

Treated wastewater reuse in the industrial sector is another potential option. Industrial facilities can use treated wastewater for cooling system make-up water, boiler-feed water, process water, and general wash down uses. It can also be used for road maintenance and concrete production in the construction projects. Industrial reuse proposes depend on the effluent quality and in some cases it may require additional treatment.

Reuse in District Cooling

At present a huge amount of fresh water –mainly desalination- is used for district cooling in many Arab countries specially GCC countries. District cooling in residential areas could be an optional application for wastewater use in these countries. The used desalination water in district cooling is costly and the economic factor could play an important role for increasing the tertiary treated wastewater in cooling in the future.

Groundwater Aquifer Recharge

Basic challenges that need to be addressed include but not limited to:

- Quality of treated wastewater and its suitability to be injected into the aquifer system.
- Economic aspects (comparing direct reuse with aquifer recharge)
- Quality of the native groundwater and how does wastewater quality change during infiltration into groundwater aquifer unsaturated zone
- Available treatment processes and if there is any additional treatment needed.
- Distance between available produced treated wastewater and the suitable aquifer for recharge
- Aquifer layers and their hydraulic parameters
- Health risk issues
- Existing groundwater recharge, abstraction and use regulations
- Potential environmental impacts

Treated Wastewater Reuse Challenges

Agriculture and landscape irrigation	
Crop irrigation	Surface-and groundwater pollution, if not properly managed
Commercial nurseries	Marketability of crops and public acceptance
Park/school yards	Effect of water quality, particularly salts, on soils, grasses and crops
Freeways (median strips) courses, Cemeteries Greenbelts, and Residential areas	Public health concerns related to pathogens (bacteria, viruses Golf and parasites)
Industrial recycling and reuse	
Cooling boiler feed	Constituents in reclaimed wastewater cause scaling, corrosion, biological growth and fouling
Pathogens in cooling water	Public health concerns, particularly aerosol transmission of processed water
Groundwater recharge	
Groundwater replenishment and salt water intrusion control	Organic chemicals in reclaimed wastewater and their toxicological effects
Subsidence control	Total dissolved solids, nitrates and pathogens in reclaimed water
Recreational/environmental uses	
Lakes and ponds	Health concerns from bacteria and viruses
Marsh enhancement and stream flow augmentation	Eutrophication due to nitrogen and phosphorus in receiving water
Fisheries	Toxicity to aquatic life

Treated Wastewater Reuse Challenges

Non-potable urban uses	
Fire protection	Public health concerns on pathogens transmitted by aerosols
Air conditioning and Toilet flushing	Effects of water quality on scaling, corrosion, biological growth Toilet and fouling
Potable uses	
Blending in water supply	Constituents in reclaimed water, especially trace organic reservoirs chemicals and their toxicological effects
Pipe-to-pipe water supply	Aesthetics and public acceptance Health concerns about pathogen transmission, particularly viruses

Constraints of Wastewater Reuse in GCC Region
Cost

- Several studies claim that the optimal wastewater treatment level is affected by costs, hazards and benefits.
- Agricultural yields and prices may decrease according to differences between levels of nutrients needed by crops and those available in wastewater (Alkhamisi and Ahmed, 2014).
- Wastewater collection, treatment, transfer and distribution for reuse are costly especially when the treatment level is tertiary.
- Advanced Treatment (Using NF, UF and Ro) versus tertiary treated direct use
- At present there are no wastewater tariff systems and even if they exist, they hardly reflect the costs for wastewater collection and treatment, thus resulting in continuous deterioration and depredation in the collection and treatment facilities.
- Due to the bad reputation of treated wastewater, end users are reluctant or unwilling to pay for the reuse.
- In some GCC countries (KSA, UAE, Qatar and Bahrain) end users get the wastewater for free. Kuwait charges farmers very low tariffs which does not cover the real costs. On other hand, the absence of the irrigation water tariffs from traditional sources does not give incentive for wastewater reuse.

Constraints of Wastewater Reuse in GCC Region

Wastewater Reuse Regulations

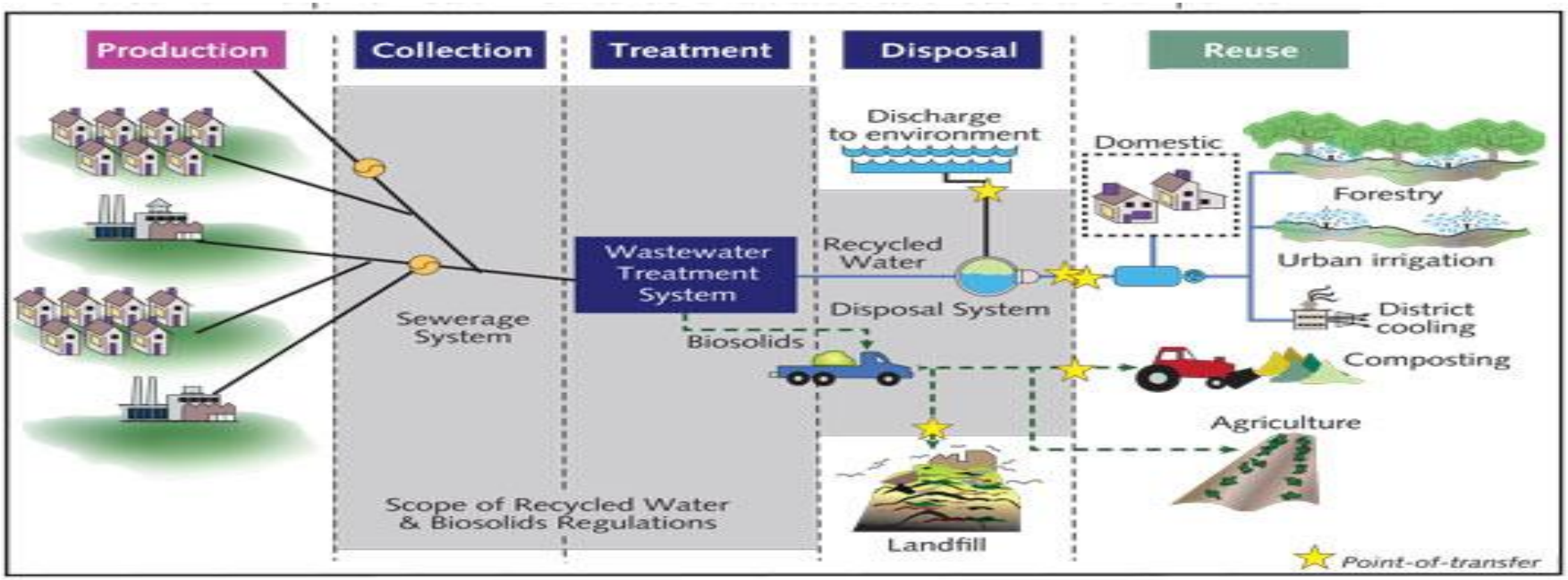
Guidelines and standards for treated wastewater reuse from the collection to the reuse are missing in many GCC countries. These regulations are very essential to control and ensure visibility and transparency in the whole wastewater cycle from collection, treatment to reuse. However these regulation and standards will help to protect public health and the environment, but the main factor driving wastewater reuse strategies is the cost of collection, treatment, distribution and monitoring.

Country	Regulation		Risk Assessment	Monitoring
	Treatment	Reuse		
KSA	Yes	Yes	No	No
Oman	Yes	No	No	No
UAE	Yes	Partially	Partially	Yes
Qatar	Yes	No	No	No
Bahrain	Yes	Yes	No	No
Kuwait	Yes	Partially	Partially	Yes

Constraints of Wastewater Reuse in GCC Region

Institutional Fragmentation

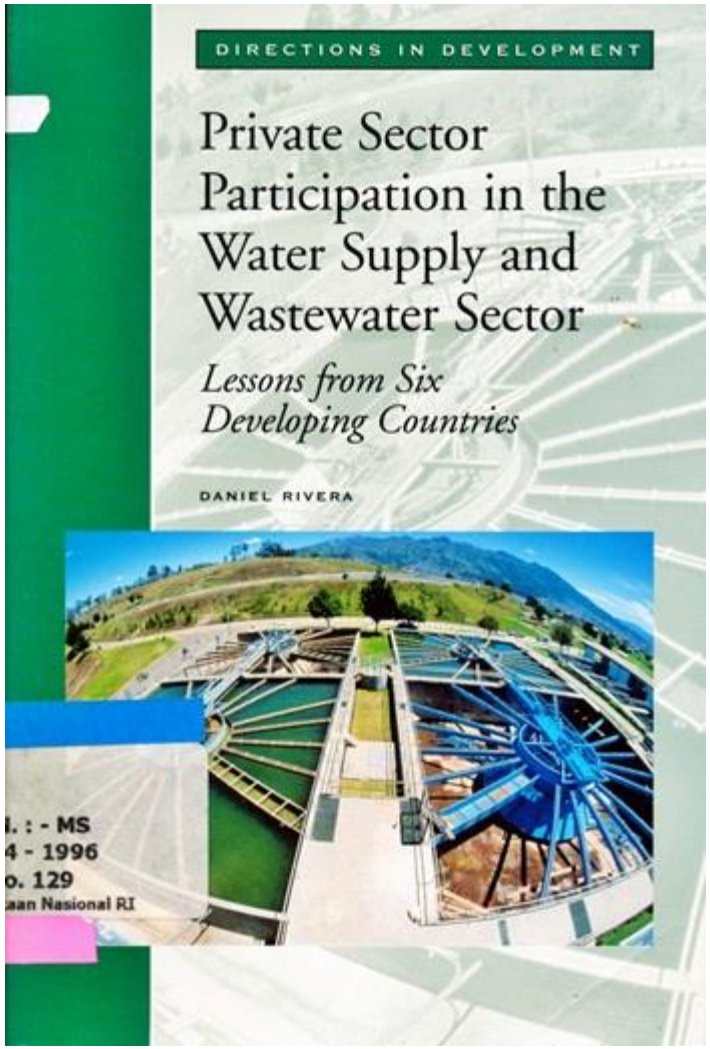
In GCC countries responsibilities for collection, treatment, transfer, monitoring and regulating of wastewater are fragmented between many agencies and intuitions which make it very difficult to develop an integrated management plan and unique strategy. There are overlapping responsibilities between agriculture authorities and other partners working in the field of collection, treatment, reuse consumer protection, and public health. Many Arab countries need to develop their own comprehensive participatory and multi-stakeholders approach for improving the intuitional framework of wastewater systems and avoid the fragmentation exist.



Constraints of Wastewater Reuse in GCC Region

Private Sector Participation

Yet there are no incentives in all Arab countries to raise the attention of the private sector in the whole cycle of wastewater from collection to reuse. The private sector would like to know their legal rights and the revenue and the protection of their investments. Getting private sector interests can be made easy by securing the right policy and legal framework that set tariffs rates that are both affordable for end users of treated wastewater and the same time could cover the capital and operational costs of the whole wastewater cycle. The policy and regulatory framework for wastewater system should have the essential elements for a finical viable wastewater reuse projects and initiatives that could be attractive to the private sector.

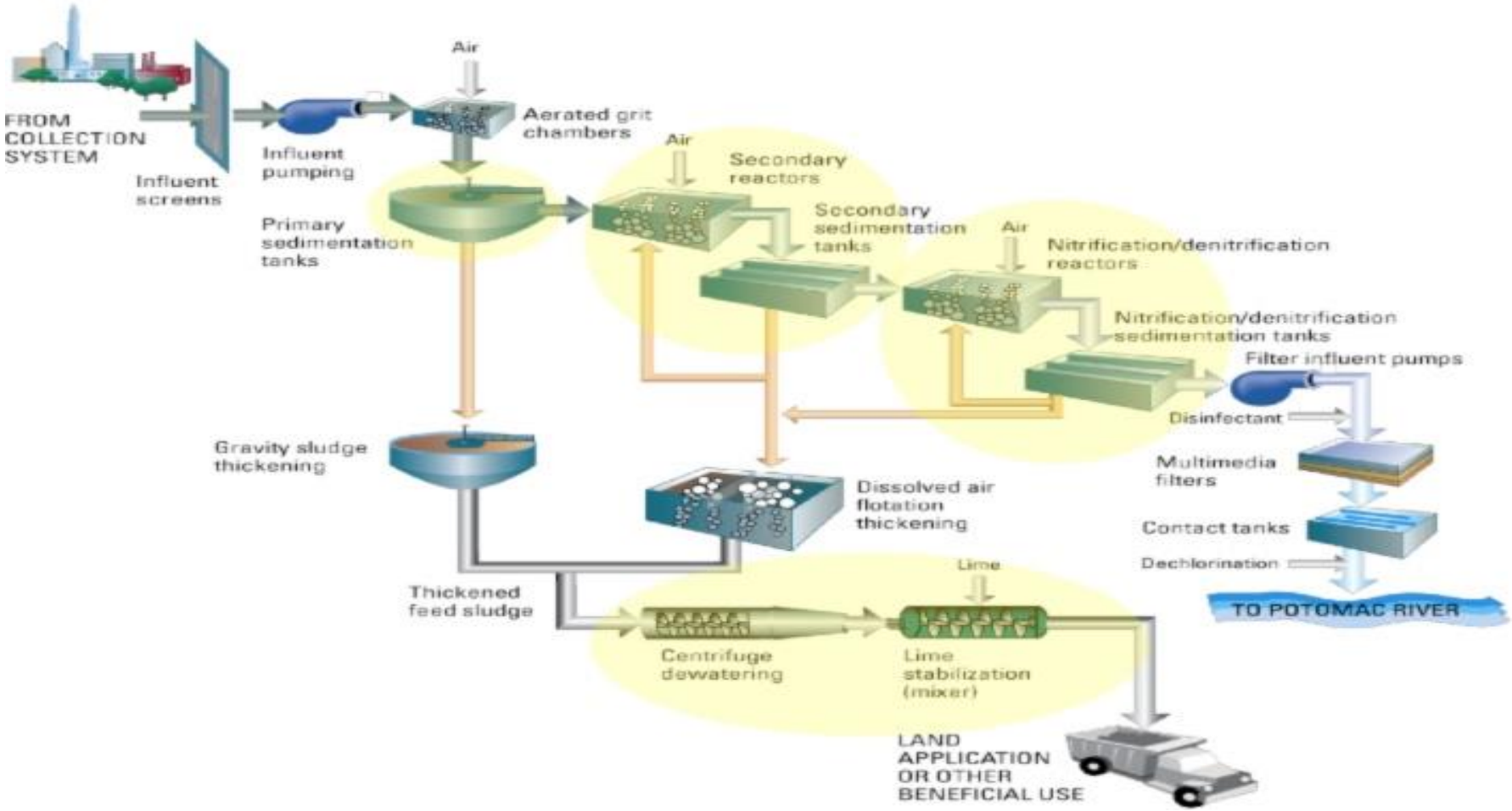


Constraints of Wastewater Reuse in GCC Region

Scio-Cultural

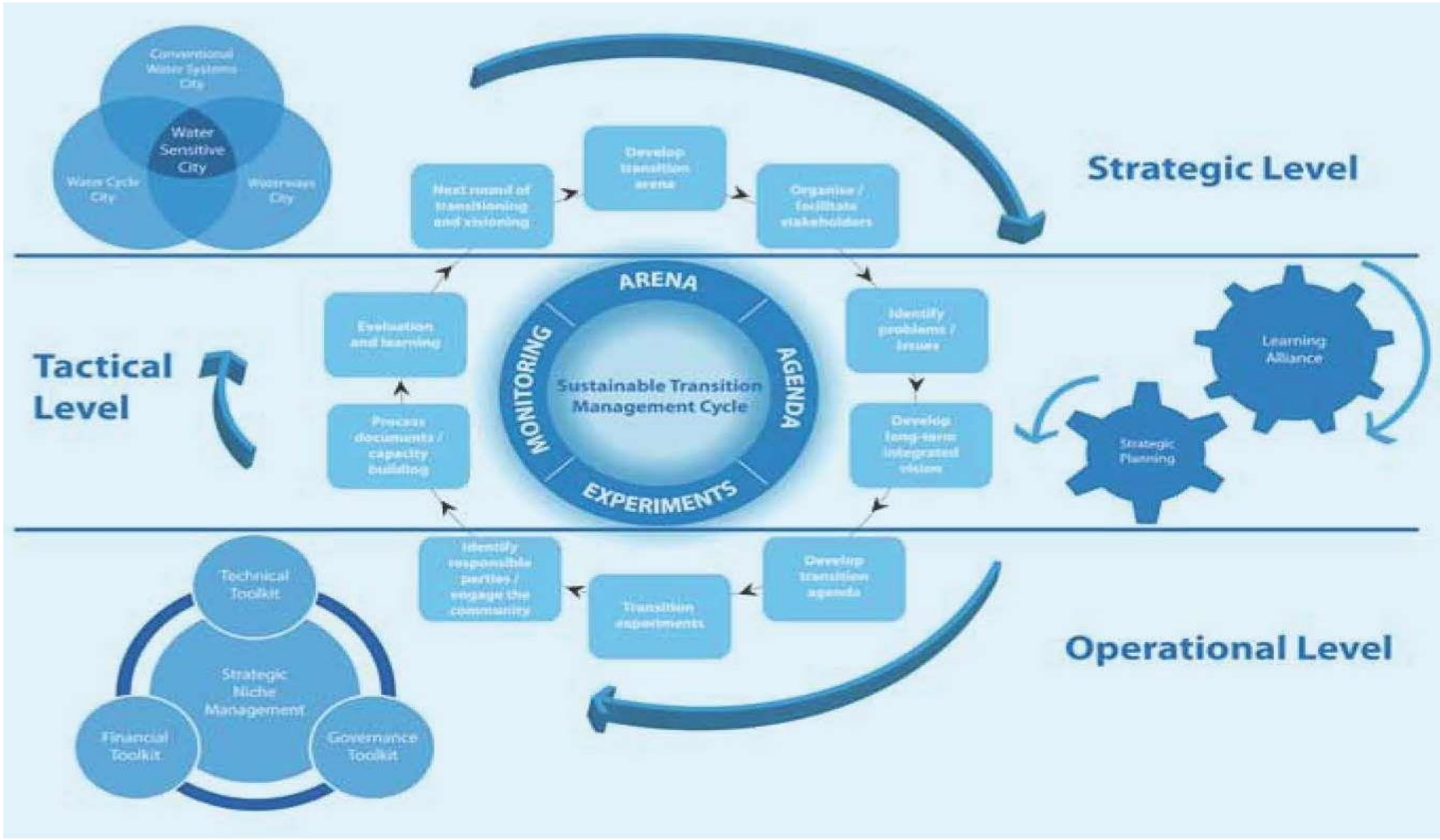
Sustainable versus Unsustainable Wastewater Management

From Collection to Reuse



Sustainable versus Unsustainable Wastewater Management

Integrated Panning

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