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An Insight into the Physical Water Scarcity Scenario of the Arab Countries

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Abstract All the Arab countries are struggling with the curse of water scarcity to different degrees of vulnerability. Most of these countries are naturally water scarce with 87% of the area being covered with desert, turning the region into an extremely arid or an arid zone, possessing only 1% share of the total water resources of the world. Due to the lack of fresh water resources in the region, the inhabitants of the region receive a low share of renewable water resources of the world equivalent to one-eighth of the share that a global citizen is blessed with. The struggle of the Arab countries pertinent to water is going to further intensify in the future in the wake of a variety of reasons including excessive demographic growth, climate change, urbanization, industrialization, lack of public awareness and inclination towards sustainable consumptive practices and sometimes affluent style of living. The excessive demand for water will further strain the already vulnerable conventional and non-conventional water supply system of the region requiring immediate technological interventions to address the problem. The water Managers and the policy makers should resort for measures of striking a balance between the water supply and demand before the situation of water scarcity culminates to a much adverse crisis of regional conflicts. There are two popular approaches of ensuring water security; a traditional water supply management approach and a more recent demand management approach. In this paper, the traditional water supply management approach for ensuring water security of the Arab countries is highlighted along with the Water supply and demand scenario of the region. In addition, some disruptive innovative techniques for managing water supply are also suggested to increase the water supply to the region. This paper limits the discussion to the water supply management approach by deliberately not touching upon the demand management approach, in order to prudently restrict the length of the paper.

Keywords Absolute Water scarcity; Population growth, climate change, Water supply Management, Desalination; Virtual water

1. Introduction

Water is that important compound whose existence has made life possible on Earth. Varieties of life forms including humans require it for their sustenance and well-being for use in domestic, Industrial and agricultural activities [1]. Water is one of the most abundant resources on the face of the earth covering around three quarters of the planet's surface. Despite its abundant occurrence on earth, the amount of fresh water available to human kind is quite less compared to the total amount available as shown in Figure 1. Around 97% of the water is saline and is trapped in the oceans whereas little more than 2% is stored in the form of glaciers, ice caps and deep ground water aquifers difficult to access leaving behind just a little less than 1% of accessible fresh water for human consumption in the form of lakes and rivers, with lakes containing most of it [2-4]. Although, even this small amount of available fresh water for human consumption is more than adequate for meeting the demands of the present population of the world, if the water is evenly distributed and wisely used. However, water is not evenly distributed across the planet. Some fortunate countries possess more water than they need

like Canada having around 100000 m^3 /capita/year of total renewable water resource (TRWR) which is by far more than the annual average of the whole world. On the other hand, some countries like Kuwait are distributed with merely a 10 m^3 / capita/year of TRWR, which is much lower than the world's threshold of absolute water scarcity putting these countries into the category of water scarce countries [4-5]. According to few interpretations, water scarcity is a situation in which the water supply of the region is inadequate to meet the long-term water demands resulting in the over exploitation of the water resources [6-7].

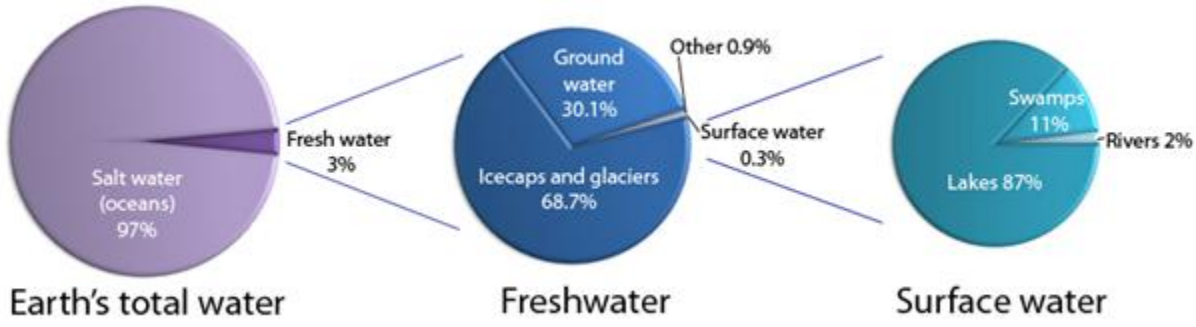


Figure 1: Earth's Water Distribution

An absolute and simple approach of categorizing the countries based on water availability is through the water stress indices like Falkenmark indicator [8-9]. According to these indices, the countries can be coined as absolute or severe water scarce countries, water scarce countries or water stressed countries if their TRWR values are less than 500 m^3 / capita/year, 1000 m^3 / capita/year and 1700 m^3 / capita/year respectively. With this categorizing mechanism, most of the countries of the Arab region are water scarce with twelve countries falling in the category of absolute or severely water scarce countries as indicated in Figure 2.

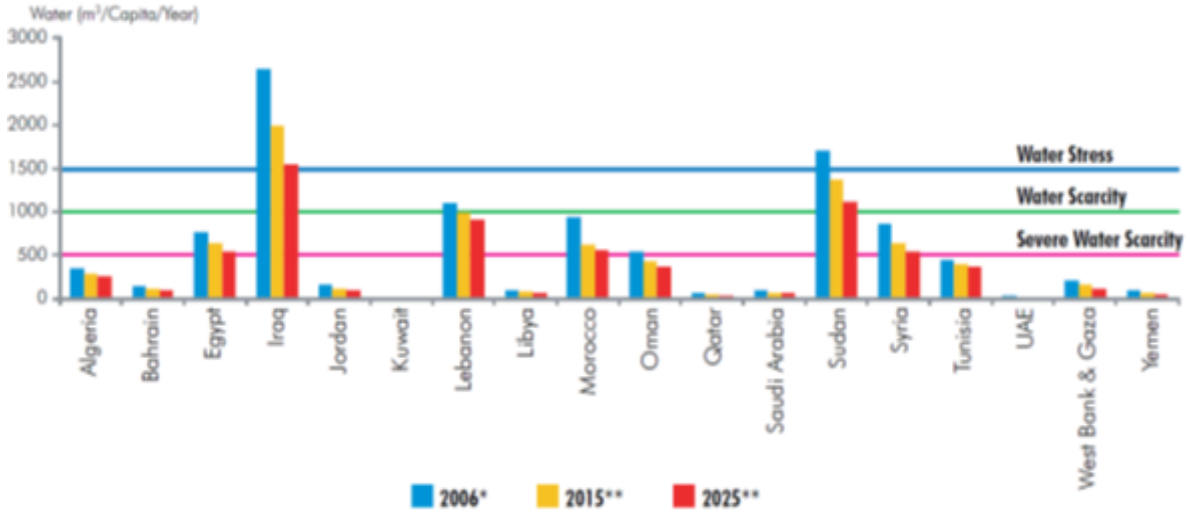


Figure 2: Projections of fresh water availability in Arab countries.

As per an estimate, in the year 2001 the average TRWR for the Arab countries was 977 m^3 / capita/year only which is projected to decline to 660 m^3 / capita/year in the year 2023 [10]. Thus, these countries are naturally water scarce with 87% of the area being desert turning the region into an extremely arid or an arid zone. The rest of the 13% of the area has mountains, narrow coastline and few rivers along with fragile aquifers. The precipitation frequency and intensity is very low compared to the rest of the world. Moreover, due to excessive temperatures the evaporation rates are also very high giving a horrible blow to the already strained surface water resources of the region. The scarcity of water can trigger myriad problems of different nature and magnitude depending upon the level of scarcity as indicated by Figure 3. Water scarcity is one of the most adverse problems faced by the world affecting the wellbeing of humanity in one way or the other [11-13]. The worst affected region of the whole world is the Arab region, which includes 22 countries namely: Algeria, Bahrain, the

Comoros Islands, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates, and Yemen. Twelve of the countries of this region are already facing absolute or severe water scarcity and more are likely to slip into this category in the near future due to the excessive demographic growth, climate change, urbanization, industrialization, lack of public awareness and inclination towards sustainable consumptive practices and sometimes affluent style of living. The demand for water will soar high but the supply will not proportionally increase, even after the paradigm shift towards non-conventional water resources by most of the Arab countries, asking for technological, social, political and administrative interventions to address the problem in a wisely and effective manner.

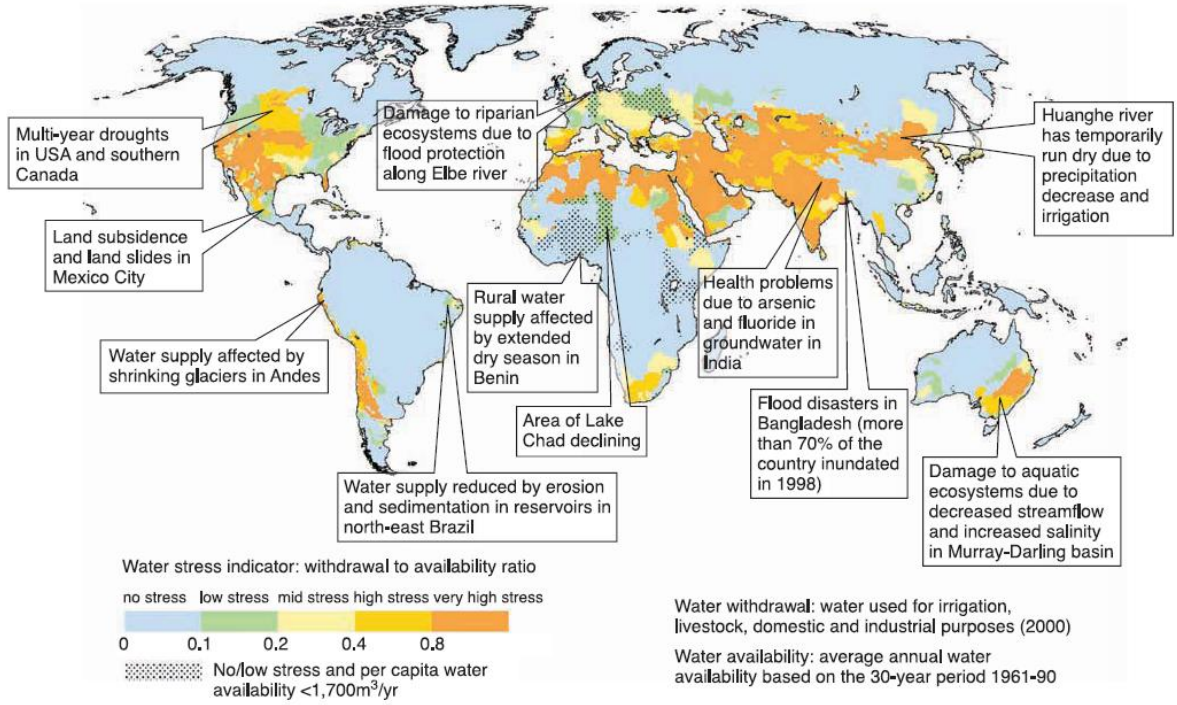


Figure 3: Water scarcity and the associated problems with it [14-15]

This paper focuses on the present scenario of water supply and demand along with the contemplation of some disruptive technological innovations in the field of water supply and demand management that could be practiced in the future for the betterment of the scenario. The future of the Arab countries in tackling the water scarcity problem lies in the integrated approaches of supply management, demand management and institutional interventions: social, political and administrative. The social, political and administrative initiatives for ensuring water security in the region fall beyond the scope of this title and therefore, deliberately left aside for inclusion in another dedicated article, orienting the present paper's focus to the technological interventions only. Water security is a desirable situation in which people have ample availability and access to the water good enough in quality and quantity to meet the requirements of livelihood, health and production needs of the population with an acceptable level of water related risks [16].

2. Fresh water availability and water scarcity scenario of the Arab countries

Most of the arab countries are plagued with low and variable rainfall, high evaporation rates, limited renewable ground water resources, severe issues of ground water salinity and dearth of fresh surface water resources in the form of rivers and lakes creating natural physical water scarcity in the region[17]. The water resources of the region are also sensitive to droughts. However, with the increase in population coupled with other factors, the scenario of the already low and meagre fresh water availability to each person in the Arab countries is fast diminishing by experiencing a very rapid depletingtrend as shown by Table 01 whereas the consumptive use for

meeting various needs is growing fast at an accelerated pacedisturbing the balance betweenalready stressed supply and demandequilibrium.

Table 1: Availability of fresh water per capita per year in some selected Arab countries from 1955 to 2050

	Water availability m^3 / capita / year							
Country	**1955[b]**	**1990[b]**	**2000[a]**	**2003[c]**	**2010[a]**	**2015[c]**	**2025[a]**	**2050[d]**
Algeria	1,770	689					332	300
Bahrain	672	179	170	153	139	120	89	
Egypt	2,561	1,123	800	770	750	600	550	510
Iraq	18,441	6,029	3,100	2,800	2,400	2,100	1,700	
Jordan	906	327	<500	150	<500	130	121	100
Kuwait				<100	<100	<100	<100	
Lebanon	3,088	1,818	900	900	800	800	867	800
Libya	4,105	1,017					359	250
Morocco	2,763	1,117					590	600
Oman	4,240	1,266	500	500	450	450	410	
Qatar	1,427	117	<100	<100	<100	<100	68	
Saudi Arabia	1,266	306	<500	400	320	250	113	
Syria	6,500	2,087	1,250	1,250	900	850	732	600
Tunisia	1,127	540					324	400
United Arab Emirates	6,195	308	<500	<400	<300	<200	176	
West Bank and Gaza	1,229	461	<500		<500		264	
Yemen	1,098	445	<500	300	250	200	152	

Sources:
a- Policies and institutions for coping with environmental aspects of water scarcity in western Asia, by Hosni Khordagui Ph.D., Lebanon http://www.unwater.org/downloads/wwwKhordagui.pdf
b- ITT industries guidebook to global water issues http://itt.com/waterbook/per_cap_country.asp
c- Economic and Social commision for Western Asia, UN, 2003 - http://www.escwa.org.lb/information/publications/edit/upload/sdpd-03-13.pdf
d- Water demand management in the Mediterranean, Hamdy A., http://www.idrc.org.sg/en/ev-42818-201-1-DO_TOPIC.html

Moreover, despite decline in water availablity, the total water withdrawal for meeting the water demand of the region for domestic, industrial and agricultural purposes is rapidly escalating as shown in Table 02, with an average consumption for agricultural activities being around 80% of the total water withdrawal. Thus, the major portion of the withdrawn water is still heavily consumed by all the Arab countries, except Bahrain, Qatar and Saudi Arabia, on agricultural activities, which shows that the region is still following unsustainable practices to the degree of aggravating the already vulnerable situation of water scarcity to a next level of serious water conflicts [18].

Table 2: Availability of fresh water resources with total withdrawal and consumption per sector for selected Arab countries in Billion Cubic meters (BCM)

Countries	**Renewable resources per capita**			**Total withdrawal**		
	1960	**1990**	**2025**	**BCM**	**% of Total**	**% of Total**
Algeria	1,704	737	354	3	16	27
Bahrain	na	na	na	0.2	na	
Egypt	2,251	1,112	645	56.4	97	93
Iraq	14,706	5,285	2,000	42.8	43	52
Jordan	529	224	91	0.8	87	77
Lebanon	2,000	1,407	809	0.8	16	24
Libya	538	154	55	2.8	404	854
Morocco	2,560	1,185	651	11	37	35
Oman	4,000	1,333	421	0.4	22	
Qatar	na	na	na	na	174	
Saudi Arabia	537	156	49	2.3	106	643
Syria	1,196	439	161	3.3	61	73
Tunisia	1,036	532	319	2.3	53	54
UAE	3,000	189	113	0.4	140	
Yemen	481	214	72	3.4	136	151

Countries	Per sector % of total					
	Domestic	Industry	Agriculture	BCM agric.need	BCM agric. actual	water use efficiency
Algeria	22	4	74	1.45	3.94	37
Bahrain	60	36	4			
Egypt	7	5	88	28.51	54	53
Iraq	3	5	92	11.2	39.38	28
Jordan	29	6	65	0.29	0.68	43
Lebanon	11	4	85	0.42	1.06	40
Libya	15	10	75	2.56	5.13	50
Morocco	6	3	91	4.24	10.18	42
Oman	3	3	94			
Qatar	36	26	38			
Saudi Arabia	45	51	4	6.68	15.42	43
Syria	7	10	83	8.53	18.96	45
Tunisia	13	7	80	1.21	2.43	50
UAE	11	9	80			
Yemen	5	2	93	2.48	6.19	40

Sources: A strategy for Managing water in the MENA 1993
AQUASTAT FAO's information System on Water and Agriculture 2001. www.fao.org/ag/agl/aglw/aquastat/water_res/waterres_tab.htm

Another important contributing factor in the stretching out and amplification of the water scarcity problem of the Arab region is the continuous and massive urbanization of the region which might have more adverse effect in the future on the water scarcity scenario than could have merely by an increase in population[19]. Urbanisation brings with it lots of changes like more water demand for landscape irrigation, development of new colonies to accommodate the influx of people, meeting the change in water consumption pattern to satisfy the affluent life style, industrial growth and power generation, increasing use of water in municipal and agricultural activities. All these demanding factors would have a more pronounced effect especially on the regions of the world facing water scarcity, triggering a sharp increase in the competition between the allocation of water for municipal use and agriculture irrigation needs [20].

The Arab region is going to experience a further decline in precipitation levels and increased frequency of droughts in the future with change in climate. The region will experience degradation of land, increase in evaporation rates, alterations in runoff patterns, water quality deterioration, and decline in the reserves of non-renewable water resources. All these factors will further strain the available water supply and its productive capacity [21-26]). In addition, the heavy subsidies on water enjoyed by the population residing in the region, public reluctance towards the reuse and recycling of treated wastewater coupled with their lack of awareness, changing life style, pollution of the existing water resources and unsustainable water consumption will further spoil the already vulnerable balance between the water supply and demand.

3. Present Scenario of Water Supply and Demand in the Arab Region

Traditionally, to meet their demands of water, most of the Arab countries used to rely heavily on the available conventional water resources in the form of few surface water resources and ground water aquifer that were and are still inadequate to fulfill all their requirements. Some countries receive the runoff from the other countries but the amount was so low that the people were always in search of water and the struggle varied from a drink of clean water to meeting their other necessary demands depending upon the level of adversity a particular country faced. Except for a few countries like, Mauritania, Comoros, Iraq, Somalia, South Sudan and Lebanon, most of the countries of the region were not having enough supply of conventional water to meet their demands. However, with the technological advancement and the economic growth of the region, a transition from a heavy reliance on the conventional water resources to the non-conventional water resources like, desalination, virtual water, recycling and reuse of treated wastewater along with rainwater harvesting was made. This augmentation of the conventional water resources with the non-conventional water resources has strengthened the water supply scenario of most of the countries of the region as shown in Table 03.

Table 3: Water availability in some of the Arab countries from Conventional and non-conventional sources

Country	Conventional water resource (MCM)			Non-conventional water resources (MCM)	
	Surface water	Groundwater recharge	Groundwater use	Desalination	Wastewater and drainage reuse
Lebanon	2,500	600	240		2
Oman	918	550	1,644	51	23
West bank and Gaza	30	185	200	0.5	2
Yemen	2,250	1,400	2,200	9	52
Jordan	350	277	486	2.5	61
Bahrain	0.2	100	258	75	17.7 (3)
Saudi Arabia	2,230	3,850	14,430	795	131 (24)
Qatar	1.4	85	185	131	28
United Arab Emirates	185	130	900	455	108
Iraq	70,370	2,000	513	7.4	1,500
Syria	16,375	5,100	3,500	2	1,447
Egypt	55,500	4,100	4,850	6.6	3,800
Kuwait	0.1	160	405	388	30

(values in brackets are drainage water reuse)

'Shared groundwater resources in the ESCWA region: the need, potential benefits and requirements for enhanced cooperation,' paper presented at the Expert Group Meeting on Legal Aspects of the Management of Shared Water Resources, Sharm El-Sheikh, Egypt, 8–11 June 2007 – cited in "Sectoral Water Allocation Policies in Selected ESCWA Countries", Economic and Social Commission for Western Asia of the United Nations. November 2003. 5

With the transition from the dependency on the conventional water resources to the exploitation of new alternatives in the form of desalination of sea water and others, more and more countries of the region are presently able to provide improved drinking water access to their population as can be witnessed from the data presented in the Figure 1.

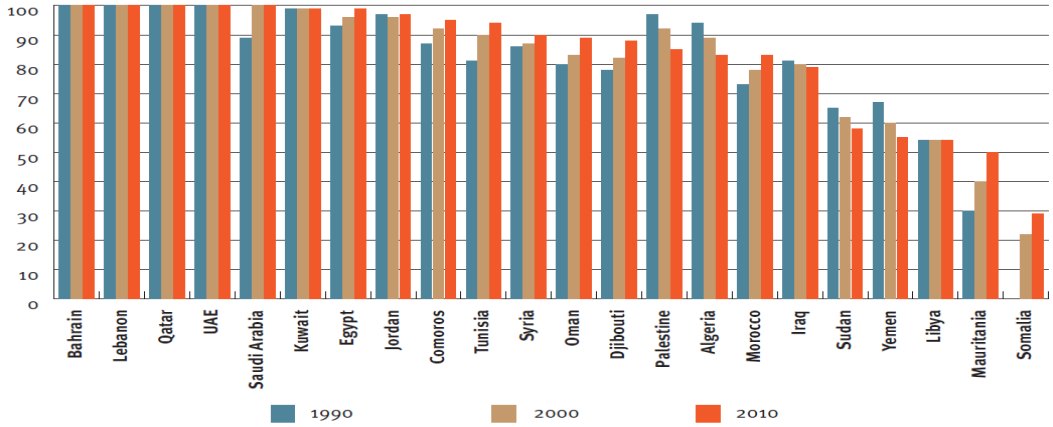
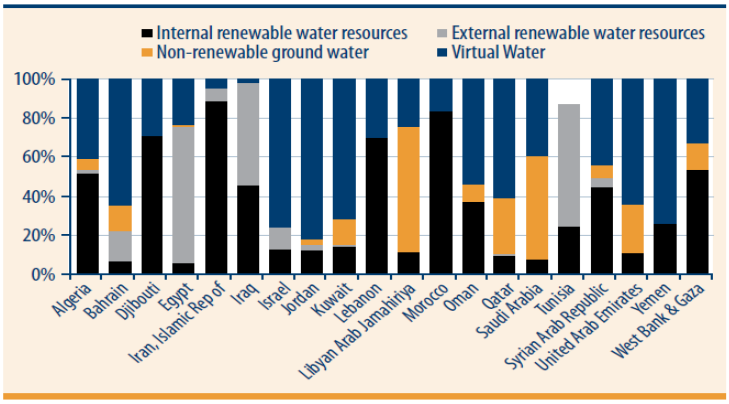


Figure 1: Country wise trend in population having access to improved drinking water sources in the Arab countries in 1990, 2000 and 2010.

Most of the countries of the Arab region are fast moving from their total dependency on conventional water resources to the non-conventional water resources with desalination presently being the favorite option. More countries of the region are installing and commissioning desalination plants at a rapid pace to meet their water demands [19, 27-28]. In addition, the countries of the region are also resorting virtual water trade with different degree of reliance on it as indicated in Figure 2.



Source: World Bank 2007.

Figure 2: Share of virtual water, renewable and non-renewable water in the Arab countries [29]

All the current available water supply alternatives augmented with the conventional water resources are just capable enough to meet the water requirements of the present population of the region. However, with the increase in population, climate change, urbanization, industrialization and changing life style coupled with pollution, public unawareness and unsustainable water consumption, the system may cease to perform requiring improvement and disruptive innovative intervention.

4. Future approaches in bridging the gap between water supply and demand

These are merely the proposals or ideas that can be further analysed and implemented based on the feasibility and utility. The possibilities are there for improvement and the whole responsibility lies on the shoulders of engineers, government and public to bring about a change the way water is being utilised and conserved. The following paragraph on efficient use of water would definitely guide many of the involved. Following provisions can be exercised to increase the water supply of the region:

- Rainwater should be captured by extensively opting best rainwater harvesting practices.
- Assessment of the existing rainwater harvesting structures to know their capacity in order to enhance it further.
- Construction of mini and macro dams in the region to store the surface water for future use.
- Augmenting the conventional water supply with desalination of sea water by using renewable energy.
- Encouraging the recycling and reuse of treated industrial and domestic waste water.
- Treated grey water should be used for the purposes shown in Figure 3.
- Encourage virtual water imports.
- Raise the awareness among the masses to efficiently consume water.
- Properly maintain water distribution networks avoiding any leakages.
- Practicing recharge of ground water and cloud seeding.
- Use of advanced water saving devices.
- Implementation of appropriate pricing policy by metering the water supply.
- Increase the water supply to meet the growing demands [30].

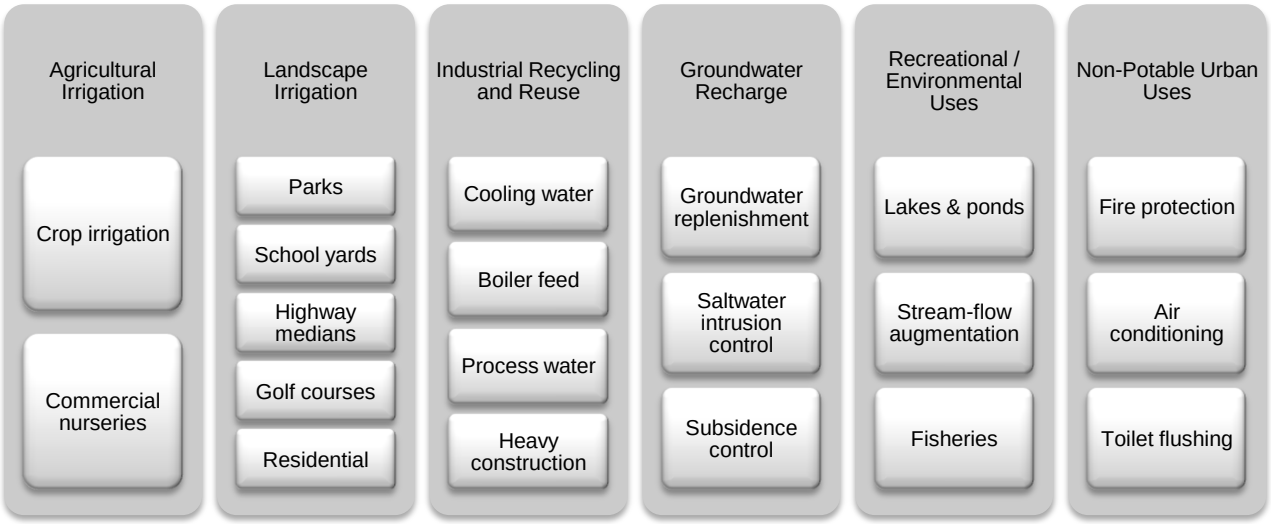


Figure 3: Grey water Reuse

5. Conclusion

Undoubtedly, the countries of the Arab region are struggling with the scarcity of water to different degrees of vulnerability with most of them being under absolute scarcity and other few are at the cusp of becoming absolute water scarce. The future ahead is very much alarming for this region. Although, the current unsustainable practices such as abstraction of groundwater and dependence on high-energy solutions to solve water problems are able to provide the population with water for the time being but the system cannot remain sustainable for long in this fashion, if appropriate measures are not taken. In light of these situations, novel

technological interventions are becoming the need of the times to bring about a change the way water is being supplied and utilized. The full dependency on one particular technology may paralyse the functioning in the near future compelling the water managers and scientists to look beyond the available options and resort for better ways of improving the practices.

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