Water Risk Filter

Country Overview - Saudi Arabia

Water Indicators

Indicator	Value	Description	Source
Overall Basin Risk (score)	2.80	Overall Basin Risk (score)	
Overall Basin Risk (rank)	63	Overall Basin Risk (rank)	
Physical risk (score)	2.85	Physical risk (score)	
Physical risk (rank)	70	Physical risk (rank)	
Regulatory risk (score)	2.72	Regulatory risk (score)	
Regulatory risk (rank)	119	Regulatory risk (rank)	
Reputation risk (score)	2.75	Reputation risk (score)	
Reputation risk (rank)	80	Reputation risk (rank)	
1. Quantity - Scarcity (score)	4.00	1. Quantity - Scarcity (score)	
1. Quantity - Scarcity (rank)	10	1. Quantity - Scarcity (rank)	
2. Quantity - Flooding (score)	2.34	2. Quantity - Flooding (score)	
2. Quantity - Flooding (rank)	145	2. Quantity - Flooding (rank)	
3. Quality (score)	1.24	3. Quality (score)	
3. Quality (rank)	176	3. Quality (rank)	
4. Ecosystem Service Status (score)	1.50	4. Ecosystem Service Status (score)	
4. Ecosystem Service Status (rank)	168	4. Ecosystem Service Status (rank)	
5. Enabling Environment (Policy & Laws) (score)	3.90	5. Enabling Environment (Policy & Laws) (score)	
5. Enabling Environment (Policy & Laws) (rank)	16	5. Enabling Environment (Policy & Laws) (rank)	
6. Institutions and Governance (score)	3.00	6. Institutions and Governance (score)	
6. Institutions and Governance (rank)	91	6. Institutions and Governance (rank)	
7. Management Instruments (score)	1.88	7. Management Instruments (score)	
7. Management Instruments (rank)	156	7. Management Instruments (rank)	
8 - Infrastructure & Finance (score)	1.20	8 - Infrastructure & Finance (score)	
8 - Infrastructure & Finance (rank)	143	8 - Infrastructure & Finance (rank)	
9. Cultural Diversity (score)	1.00	9. Cultural importance (score)	
9. Cultural Diversity (rank)	144	9. Cultural importance (rank)	
10. Biodiversity Importance (score)	3.00	10. Biodiversity importance (score)	

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Indicator	Value	Description	Source
10. Biodiversity Importance (rank)	128	10. Biodiversity importance (rank)	
11. Media Scrutiny (score)	3.55	11. Media Scrutiny (score)	
11. Media Scrutiny (rank)	29	11. Media Scrutiny (rank)	
12. Conflict (score)	2.46	12. Conflict (score)	
12. Conflict (rank)	105	12. Conflict (rank)	
1.0 - Aridity (score)	4.28	The aridity risk indicator is based on the Global Aridity Index (Global-Aridity) and Global Potential Evapo-Transpiration (Global-PET) Geospatial data sets by Trabucco and Zomer (2009). These data sets provide information about the potential availability of water in regions with low water demand, thus they are used in the Water Risk Filter 5.0 to better account for deserts and other arid areas in the risk assessment.	Trabucco, A., & Zomer, R. J. (2009). Global potential evapo-transpiration (Global-PET) and global aridity index (Global-Aridity) geo-database. CGIAR consortium for spatial information.
1.0 - Aridity (rank)	7	The aridity risk indicator is based on the Global Aridity Index (Global-Aridity) and Global Potential Evapo-Transpiration (Global-PET) Geospatial data sets by Trabucco and Zomer (2009). These data sets provide information about the potential availability of water in regions with low water demand, thus they are used in the Water Risk Filter 5.0 to better account for deserts and other arid areas in the risk assessment.	Trabucco, A., & Zomer, R. J. (2009). Global potential evapo-transpiration (Global-PET) and global aridity index (Global-Aridity) geo-database. CGIAR consortium for spatial information.
1.1 - Water Depletion (score)	3.03	The water depletion risk indicator is based on annual average monthly net water depletion from Brauman et al. (2016). Their analysis is based on model outputs from the newest version of the integrated water resources model WaterGAP3 which measures water depletion as the ratio of water consumption-to-availability.	Brauman, K. A., Richter, B. D., Postel, S., Malsy, M., & Flörke, M. (2016). Water depletion: An improved metric for incorporating seasonal and dry-year water scarcity into water risk assessments. Elem Sci Anth, 4.
1.1 - Water Depletion (rank)	31	The water depletion risk indicator is based on annual average monthly net water depletion from Brauman et al. (2016). Their analysis is based on model outputs from the newest version of the integrated water resources model WaterGAP3 which measures water depletion as the ratio of water consumption-to-availability.	Brauman, K. A., Richter, B. D., Postel, S., Malsy, M., & Flörke, M. (2016). Water depletion: An improved metric for incorporating seasonal and dry-year water scarcity into water risk assessments. Elem Sci Anth, 4.
1.2 - Baseline Water Stress (score)	3.74	World Resources Institute's Baseline Water Stress measures the ratio of total annual water withdrawals to total available annual renewable supply, accounting for upstream consumptive use. A higher percentage indicates more competition among users.	Hofste, R., Kuzma, S., Walker, S., ... & Sutanudjaja, E.H. (2019). Aqueduct 3.0: Updated decision relevant global water risk indicators. Technical note. Washington, DC: World Resources Institute.

Indicator	Value	Description	Source
1.2 - Baseline Water Stress (rank)	26	World Resources Institute’s Baseline Water Stress measures the ratio of total annual water withdrawals to total available annual renewable supply, accounting for upstream consumptive use. A higher percentage indicates more competition among users.	Hofste, R., Kuzma, S., Walker, S., ... & Sutanudjaja, E.H. (2019). Aqueduct 3.0: Updated decision relevant global water risk indicators. Technical note. Washington, DC: World Resources Institute.
1.3 - Blue Water Scarcity (score)	5.00	The blue water scarcity risk indicator is based on Mekonnen and Hoekstra (2016) global assessment of blue water scarcity on a monthly basis and at high spatial resolution (grid cells of 30 × 30 arc min resolution). Blue water scarcity is calculated as the ratio of the blue water footprint in a grid cell to the total blue water availability in the cell. The time period analyzed in this study ranges from 1996 to 2005.	Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. Science advances, 2(2), e1500323.
1.3 - Blue Water Scarcity (rank)	3	The blue water scarcity risk indicator is based on Mekonnen and Hoekstra (2016) global assessment of blue water scarcity on a monthly basis and at high spatial resolution (grid cells of 30 × 30 arc min resolution). Blue water scarcity is calculated as the ratio of the blue water footprint in a grid cell to the total blue water availability in the cell. The time period analyzed in this study ranges from 1996 to 2005.	Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. Science advances, 2(2), e1500323.
1.4 - Projected Change in Water Discharge (by ~2050) (score)	2.44	This risk indicator is based on multi-model simulation that applies both global climate and hydrological models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). To estimate the change at 2°C of global warming above 1980-2010 levels, simulated annual water discharge was averaged over a 31-year period with 2°C mean warming. Results are expressed in terms of relative change (%) in probability between present day (1980-2010) conditions and 2°C scenarios by 2050.	Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N. W., Clark, D. B., ... & Gosling, S. N. (2014). Multimodel assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences, 111(9), 3245-3250.
1.4 - Projected Change in Water Discharge (by ~2050) (rank)	44	This risk indicator is based on multi-model simulation that applies both global climate and hydrological models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). To estimate the change at 2°C of global warming above 1980-2010 levels, simulated annual water discharge was averaged over a 31-year period with 2°C mean warming. Results are expressed in terms of relative change (%) in probability between present day (1980-2010) conditions and 2°C scenarios by 2050.	Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N. W., Clark, D. B., ... & Gosling, S. N. (2014). Multimodel assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences, 111(9), 3245-3250.

Water Risk Filter

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
1.5 - Drought Frequency Probability (score)	4.75	This risk indicator is based on the Standardized Precipitation and Evaporation Index (SPEI). Vicente-Serrano et al. (2010) developed this multi-scalar drought index applying both precipitation and temperature data to detect, monitor and analyze different drought types and impacts in the context of global warming. The mathematical calculations used for SPEI are similar to the Standard Precipitation Index (SPI), but it has the advantage to include the role of evapotranspiration.	Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2010). A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. Journal of climate, 23(7), 1696-1718.
1.5 - Drought Frequency Probability (rank)	18	This risk indicator is based on the Standardized Precipitation and Evaporation Index (SPEI). Vicente-Serrano et al. (2010) developed this multi-scalar drought index applying both precipitation and temperature data to detect, monitor and analyze different drought types and impacts in the context of global warming. The mathematical calculations used for SPEI are similar to the Standard Precipitation Index (SPI), but it has the advantage to include the role of evapotranspiration.	Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2010). A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. Journal of climate, 23(7), 1696-1718.
1.6 - Projected Change in Drought Occurrence (by ~2050) (score)	3.00	This risk indicator is based on multi-model simulation that applies both global climate and drought models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) . A drought threshold for pre-industrial conditions was calculated based on time-series averages. Results are expressed in terms of relative change (%) in probability between pre-industrial and 2°C scenarios.	Frieler, K., Lange, S., Piontek, F., Reyer, C. P., Schewe, J., Warszawski, L., ... & Geiger, T. (2017). Assessing the impacts of 1.5 C global warming–simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b). Geoscientific Model Development.
1.6 - Projected Change in Drought Occurrence (by ~2050) (rank)	92	This risk indicator is based on multi-model simulation that applies both global climate and drought models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) . A drought threshold for pre-industrial conditions was calculated based on time-series averages. Results are expressed in terms of relative change (%) in probability between pre-industrial and 2°C scenarios.	Frieler, K., Lange, S., Piontek, F., Reyer, C. P., Schewe, J., Warszawski, L., ... & Geiger, T. (2017). Assessing the impacts of 1.5 C global warming–simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b). Geoscientific Model Development.
2.1 - Estimated Flood Occurrence (score)	2.35	This risk indicator is based on the recurrence of floods within the 34-year time frame period of 1985 to 2019. The occurrence of floods within a given location was estimated using data from Flood Observatory, University of Colorado. The Flood Observatory use data derived from a wide variety of news, governmental, instrumental, and remote sensing source.	Brakenridge, G. R. (2019). Global active archive of large flood events. Dartmouth Flood Observatory, University of Colorado.
2.1 - Estimated Flood Occurrence (rank)	145	This risk indicator is based on the recurrence of floods within the 34-year time frame period of 1985 to 2019. The occurrence of floods within a given location was estimated using data from Flood Observatory, University of Colorado. The Flood Observatory use data derived from a wide variety of news, governmental, instrumental, and remote sensing source.	Brakenridge, G. R. (2019). Global active archive of large flood events. Dartmouth Flood Observatory, University of Colorado.

Indicator	Value	Description	Source
2.2 - Projected Change in Flood Occurrence (by ~2050) (score)	2.18	This risk indicator is based on multi-model simulation that applies both global climate and drought models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). The magnitude of the flood event was defined based on 100-year return period for pre-industrial conditions. Results are expressed in terms of change (%) in probability between pre-industrial and 2°C scenarios.	Frieler, K., Lange, S., Piontek, F., Reyer, C. P., Schewe, J., Warszawski, L., ... & Geiger, T. (2017). Assessing the impacts of 1.5 C global warming–simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b). Geoscientific Model Development.
2.2 - Projected Change in Flood Occurrence (by ~2050) (rank)	105	This risk indicator is based on multi-model simulation that applies both global climate and drought models from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). The magnitude of the flood event was defined based on 100-year return period for pre-industrial conditions. Results are expressed in terms of change (%) in probability between pre-industrial and 2°C scenarios.	Frieler, K., Lange, S., Piontek, F., Reyer, C. P., Schewe, J., Warszawski, L., ... & Geiger, T. (2017). Assessing the impacts of 1.5 C global warming–simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b). Geoscientific Model Development.
3.1 - Surface Water Contamination Index (score)	1.24	The underlying data for this risk indicator is based on a broad suite of pollutants with well-documented direct or indirect negative effects on water security for both humans and freshwater biodiversity, compiled by Vörösmarty et al. (2010). The negative effects are specific to individual pollutants, ranging from impacts mediated by eutrophication such as algal blooms and oxygen depletion (e.g., caused by phosphorus and organic loading) to direct toxic effects (e.g., caused by pesticides, mercury). The overall Surface Water Contamination Index is calculated based on a range of key pollutants with different weightings according to the level of their negative effects on water security for both humans and freshwater biodiversity: soil salinization (8%), nitrogen (12%) and phosphorus (P, 13%) loading, mercury deposition (5%), pesticide loading (10%), sediment loading (17%), organic loading (as Biological Oxygen Demand, BOD; 15%), potential acidification (9%), and thermal alteration (11%).	Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., ... & Davies, P. M. (2010). Global threats to human water security and river biodiversity. Nature, 467(7315), 555.

Indicator	Value	Description	Source
3.1 - Surface Water Contamination Index (rank)	176	The underlying data for this risk indicator is based on a broad suite of pollutants with well-documented direct or indirect negative effects on water security for both humans and freshwater biodiversity, compiled by Vörösmarty et al. (2010). The negative effects are specific to individual pollutants, ranging from impacts mediated by eutrophication such as algal blooms and oxygen depletion (e.g., caused by phosphorus and organic loading) to direct toxic effects (e.g., caused by pesticides, mercury). The overall Surface Water Contamination Index is calculated based on a range of key pollutants with different weightings according to the level of their negative effects on water security for both humans and freshwater biodiversity: soil salinization (8%), nitrogen (12%) and phosphorus (P, 13%) loading, mercury deposition (5%), pesticide loading (10%), sediment loading (17%), organic loading (as Biological Oxygen Demand, BOD; 15%), potential acidification (9%), and thermal alteration (11%).	Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., ... & Davies, P. M. (2010). Global threats to human water security and river biodiversity. Nature, 467(7315), 555.
4.1 - Fragmentation Status of Rivers (score)	1.61	This risk indicator is based on the data set by Grill et al. (2019) mapping the world's free-flowing rivers. Grill et al. (2019) compiled a geometric network of the global river system and associated attributes, such as hydro-geometric properties, as well as pressure indicators to calculate an integrated connectivity status index (CSI). While only rivers with high levels of connectivity in their entire length are classified as free-flowing, rivers of CSI < 95% are considered as fragmented at a certain degree.	Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., ... & Macedo, H. E. (2019). Mapping the world's free-flowing rivers. Nature, 569(7755), 215.
4.1 - Fragmentation Status of Rivers (rank)	152	This risk indicator is based on the data set by Grill et al. (2019) mapping the world's free-flowing rivers. Grill et al. (2019) compiled a geometric network of the global river system and associated attributes, such as hydro-geometric properties, as well as pressure indicators to calculate an integrated connectivity status index (CSI). While only rivers with high levels of connectivity in their entire length are classified as free-flowing, rivers of CSI < 95% are considered as fragmented at a certain degree.	Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., ... & Macedo, H. E. (2019). Mapping the world's free-flowing rivers. Nature, 569(7755), 215.
4.2 - Catchment Ecosystem Services Degradation Level (tree cover loss) (score)	1.00	For this risk indicator, tree cover loss was applied as a proxy to represent catchment ecosystem services degradation since forests play an important role in terms of water regulation, supply and pollution control. The forest cover data is based on Hansen et al.'s global Landsat data at a 30-meter spatial resolution to characterize forest cover and change. The authors defined trees as vegetation taller than 5 meters in height, and forest cover loss as a stand-replacement disturbance, or a change from a forest to non-forest state, during the period 2000 – 2018.	Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A. A., Tyukavina, A., ... & Kommareddy, A. (2013). High-resolution global maps of 21st-century forest cover change. science, 342(6160), 850-853.

Indicator	Value	Description	Source
4.2 - Catchment Ecosystem Services Degradation Level (tree cover loss) (rank)	168	For this risk indicator, tree cover loss was applied as a proxy to represent catchment ecosystem services degradation since forests play an important role in terms of water regulation, supply and pollution control. The forest cover data is based on Hansen et al.'s global Landsat data at a 30-meter spatial resolution to characterize forest cover and change. The authors defined trees as vegetation taller than 5 meters in height, and forest cover loss as a stand-replacement disturbance, or a change from a forest to non-forest state, during the period 2000 – 2018.	Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A. A., Tyukavina, A., ... & Kommareddy, A. (2013). High-resolution global maps of 21st-century forest cover change. science, 342(6160), 850-853.
4.3 - Projected Impacts on Freshwater Biodiversity (score)	2.40	The study by Tedesco et al. (2013) to project changes [% increase or decrease] in extinction rate by ~2090 of freshwater fish due to water availability loss from climate change is used as a proxy to estimate the projected impacts on freshwater biodiversity.	Tedesco, P. A., Oberdorff, T., Cornu, J. F., Beauchard, O., Brosse, S., Dürr, H. H., ... & Hugueny, B. (2013). A scenario for impacts of water availability loss due to climate change on riverine fish extinction rates. Journal of Applied Ecology, 50(5), 1105-1115.
4.3 - Projected Impacts on Freshwater Biodiversity (rank)	96	The study by Tedesco et al. (2013) to project changes [% increase or decrease] in extinction rate by ~2090 of freshwater fish due to water availability loss from climate change is used as a proxy to estimate the projected impacts on freshwater biodiversity.	Tedesco, P. A., Oberdorff, T., Cornu, J. F., Beauchard, O., Brosse, S., Dürr, H. H., ... & Hugueny, B. (2013). A scenario for impacts of water availability loss due to climate change on riverine fish extinction rates. Journal of Applied Ecology, 50(5), 1105-1115.
5.1 - Freshwater Policy Status (SDG 6.5.1) (score)	4.00	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "National Water Resources Policy" indicator, which corresponds to one of the three national level indicators under the Enabling Environment category.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
5.1 - Freshwater Policy Status (SDG 6.5.1) (rank)	17	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "National Water Resources Policy" indicator, which corresponds to one of the three national level indicators under the Enabling Environment category.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
5.2 - Freshwater Law Status (SDG 6.5.1) (score)	4.00	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "National Water Resources Law(s)" indicator, which corresponds to one of the three national level indicators under the Enabling Environment category. For SDG 6.5.1, enabling environment depicts the conditions that help to support the implementation of IWRM, which includes legal and strategic planning tools for IWRM.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.

Indicator	Value	Description	Source
5.2 - Freshwater Law Status (SDG 6.5.1) (rank)	15	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation “National Water Resources Law(s)” indicator, which corresponds to one of the three national level indicators under the Enabling Environment category. For SDG 6.5.1, enabling environment depicts the conditions that help to support the implementation of IWRM, which includes legal and strategic planning tools for IWRM.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
5.3 - Implementation Status of Water Management Plans (SDG 6.5.1) (score)	3.00	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation “National IWRM plans” indicator, which corresponds to one of the three national level indicators under the Enabling Environment category. For SDG 6.5.1, enabling environment depicts the conditions that help to support the implementation of IWRM, which includes legal and strategic planning tools for IWRM.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
5.3 - Implementation Status of Water Management Plans (SDG 6.5.1) (rank)	70	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation “National IWRM plans” indicator, which corresponds to one of the three national level indicators under the Enabling Environment category. For SDG 6.5.1, enabling environment depicts the conditions that help to support the implementation of IWRM, which includes legal and strategic planning tools for IWRM.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
6.1 - Corruption Perceptions Index (score)	3.00	This risk Indicator is based on the latest Transparency International’s data: the Corruption Perceptions Index 2018. This index aggregates data from a number of different sources that provide perceptions of business people and country experts on the level of corruption in the public sector.	Transparency International (2019). Corruption Perceptions Index 2018. Berlin: Transparency International.
6.1 - Corruption Perceptions Index (rank)	109	This risk Indicator is based on the latest Transparency International’s data: the Corruption Perceptions Index 2018. This index aggregates data from a number of different sources that provide perceptions of business people and country experts on the level of corruption in the public sector.	Transparency International (2019). Corruption Perceptions Index 2018. Berlin: Transparency International.
6.2 - Freedom in the World Index (score)	5.00	This risk indicator is based on Freedom House (2019), an annual global report on political rights and civil liberties, composed of numerical ratings and descriptive texts for each country and a select group of territories. The 2019 edition involved more than 100 analysts and more than 30 advisers with global, regional, and issue-based expertise to covers developments in 195 countries and 14 territories from January 1, 2018, through December 31, 2018.	Freedom House (2019). Freedom in the world 2019. Washington, DC: Freedom House.

Indicator	Value	Description	Source
6.2 - Freedom in the World Index (rank)	24	This risk indicator is based on Freedom House (2019), an annual global report on political rights and civil liberties, composed of numerical ratings and descriptive texts for each country and a select group of territories. The 2019 edition involved more than 100 analysts and more than 30 advisers with global, regional, and issue-based expertise to covers developments in 195 countries and 14 territories from January 1, 2018, through December 31, 2018.	Freedom House (2019). Freedom in the world 2019. Washington, DC: Freedom House.
6.3 - Business Participation in Water Management (SDG 6.5.1) (score)	1.00	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "Business Participation in Water Resources Development, Management and Use" indicator, which corresponds to one of the six national level indicators under the Institutions and Participation category.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
6.3 - Business Participation in Water Management (SDG 6.5.1) (rank)	151	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "Business Participation in Water Resources Development, Management and Use" indicator, which corresponds to one of the six national level indicators under the Institutions and Participation category.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
7.1 - Management Instruments for Water Management (SDG 6.5.1) (score)	1.00	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "Sustainable and efficient water use management" indicator, which corresponds to one of the five national level indicators under the Management Instruments category. For SDG 6.5.1, management instruments refer to the tools and activities that enable decision-makers and users to make rational and informed choices between alternative actions.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
7.1 - Management Instruments for Water Management (SDG 6.5.1) (rank)	160	This risk indicator is based on SDG 6.5.1. Degree of IWRM Implementation "Sustainable and efficient water use management" indicator, which corresponds to one of the five national level indicators under the Management Instruments category. For SDG 6.5.1, management instruments refer to the tools and activities that enable decision-makers and users to make rational and informed choices between alternative actions.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.

Indicator	Value	Description	Source
7.2 - Groundwater Monitoring Data Availability and Management (score)	3.00	This risk indicator is based on the data set by UN IGRAC (2019) to determine the level of availability of groundwater monitoring data at country level as groundwater management decisions rely strongly on data availability. The level of groundwater monitoring data availability for groundwater management is determined according to a combination of three criteria developed by WWF and IGRAC: 1) Status of country groundwater monitoring programme, 2) groundwater data availability for NGOs and 3) Public access to processed groundwater monitoring data.	UN IGRAC (2019). Global Groundwater Monitoring Network GGMN Portal. UN International Groundwater Resources Assessment Centre (IGRAC).
7.2 - Groundwater Monitoring Data Availability and Management (rank)	66	This risk indicator is based on the data set by UN IGRAC (2019) to determine the level of availability of groundwater monitoring data at country level as groundwater management decisions rely strongly on data availability. The level of groundwater monitoring data availability for groundwater management is determined according to a combination of three criteria developed by WWF and IGRAC: 1) Status of country groundwater monitoring programme, 2) groundwater data availability for NGOs and 3) Public access to processed groundwater monitoring data.	UN IGRAC (2019). Global Groundwater Monitoring Network GGMN Portal. UN International Groundwater Resources Assessment Centre (IGRAC).
7.3 - Density of Runoff Monitoring Stations (score)	4.90	The density of monitoring stations for water quantity was applied as proxy to develop this risk indicator. The Global Runoff Data Base was used to estimate the number of monitoring stations per 1000km2 of the main river system (data base access date: May 2018).	BfG (2019). Global Runoff Data Base. German Federal Institute of Hydrology (BfG).
7.3 - Density of Runoff Monitoring Stations (rank)	20	The density of monitoring stations for water quantity was applied as proxy to develop this risk indicator. The Global Runoff Data Base was used to estimate the number of monitoring stations per 1000km2 of the main river system (data base access date: May 2018).	BfG (2019). Global Runoff Data Base. German Federal Institute of Hydrology (BfG).
8.1 - Access to Safe Drinking Water (score)	1.00	This risk indicator is based on the Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (UNICEF/WHO) 2019 data. It provides estimates on the use of water, sanitation and hygiene by country for the period 2000-2017.	WHO & UNICEF (2019). Estimates on the use of water, sanitation and hygiene by country (2000-2017). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.
8.1 - Access to Safe Drinking Water (rank)	118	This risk indicator is based on the Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (UNICEF/WHO) 2019 data. It provides estimates on the use of water, sanitation and hygiene by country for the period 2000-2017.	WHO & UNICEF (2019). Estimates on the use of water, sanitation and hygiene by country (2000-2017). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.
8.2 - Access to Sanitation (score)	1.00	This risk indicator is based on the Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (UNICEF/WHO) 2019 data. It provides estimates on the use of water, sanitation and hygiene by country for the period 2000-2017.	WHO & UNICEF (2019). Estimates on the use of water, sanitation and hygiene by country (2000-2017). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.

Indicator	Value	Description	Source
8.2 - Access to Sanitation (rank)	134	This risk indicator is based on the Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (UNICEF/WHO) 2019 data. It provides estimates on the use of water, sanitation and hygiene by country for the period 2000-2017.	WHO & UNICEF (2019). Estimates on the use of water, sanitation and hygiene by country (2000-2017). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.
8.3 - Financing for Water Resource Development and Management (SDG 6.5.1) (score)	3.00	This risk indicator is based on the average 'Financing' score of UN SDG 6.5.1. Degree of IWRM Implementation database. UN SDG 6.5.1 database contains a category on financing which assesses different aspects related to budgeting and financing made available and used for water resources development and management from various sources.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
8.3 - Financing for Water Resource Development and Management (SDG 6.5.1) (rank)	93	This risk indicator is based on the average 'Financing' score of UN SDG 6.5.1. Degree of IWRM Implementation database. UN SDG 6.5.1 database contains a category on financing which assesses different aspects related to budgeting and financing made available and used for water resources development and management from various sources.	UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
9.1 - Cultural Diversity (score)	1.00	Water is a social and cultural good. The cultural diversity risk indicator was included in order to acknowledge that businesses face reputational risk due to the importance of freshwater for indigenous and traditional people in their daily life, religion and culture. This risk indicator is based on Oviedo and Larsen (2000) data set, which mapped the world's ethnolinguistic groups onto the WWF map of the world's ecoregions. This cross-mapping showed for the very first time the significant overlap that exists between the global geographic distribution of biodiversity and that of linguistic diversity.	Oviedo, G., Maffi, L., & Larsen, P. B. (2000). Indigenous and traditional peoples of the world and ecoregion conservation: An integrated approach to conserving the world's biological and cultural diversity. Gland: WWF (World Wide Fund for Nature) International.
9.1 - Cultural Diversity (rank)	144	Water is a social and cultural good. The cultural diversity risk indicator was included in order to acknowledge that businesses face reputational risk due to the importance of freshwater for indigenous and traditional people in their daily life, religion and culture. This risk indicator is based on Oviedo and Larsen (2000) data set, which mapped the world's ethnolinguistic groups onto the WWF map of the world's ecoregions. This cross-mapping showed for the very first time the significant overlap that exists between the global geographic distribution of biodiversity and that of linguistic diversity.	Oviedo, G., Maffi, L., & Larsen, P. B. (2000). Indigenous and traditional peoples of the world and ecoregion conservation: An integrated approach to conserving the world's biological and cultural diversity. Gland: WWF (World Wide Fund for Nature) International.
10.1 - Freshwater Endemism (score)	5.00	The underlying data set for this risk indicator comes from the Freshwater Ecoregions of the World (FEOW) 2015 data developed by WWF and TNC. Companies operating in basins with higher number of endemic fish species are exposed to higher reputational risks.	WWF & TNC (2015). Freshwater Ecoregions of the World.

Indicator	Value	Description	Source
10.1 - Freshwater Endemism (rank)	6	The underlying data set for this risk indicator comes from the Freshwater Ecoregions of the World (FEOW) 2015 data developed by WWF and TNC. Companies operating in basins with higher number of endemic fish species are exposed to higher reputational risks.	WWF & TNC (2015). Freshwater Ecoregions of the World.
10.2 - Freshwater Biodiversity Richness (score)	1.00	The underlying data set for this risk indicator comes from the Freshwater Ecoregions of the World (FEOW) 2015 data developed by WWF and TNC. Count of fish species is used as a representation of freshwater biodiversity richness. Companies operating in basins with higher number of fish species are exposed to higher reputational risks.	WWF & TNC (2015). Freshwater Ecoregions of the World.
10.2 - Freshwater Biodiversity Richness (rank)	189	The underlying data set for this risk indicator comes from the Freshwater Ecoregions of the World (FEOW) 2015 data developed by WWF and TNC. Count of fish species is used as a representation of freshwater biodiversity richness. Companies operating in basins with higher number of fish species are exposed to higher reputational risks.	WWF & TNC (2015). Freshwater Ecoregions of the World.
11.1 - National Media Coverage (score)	4.00	This risk indicator is based on joint qualitative research by WWF and Tecnoma (Typsa Group). It indicates how aware local residents typically are of water-related issues due to national media coverage. The status of the river basin (e.g., scarcity and pollution) is taken into account, as well as the importance of water for livelihoods (e.g., food and shelter).	WWF & Tecnoma (TYPSA Group)
11.1 - National Media Coverage (rank)	34	This risk indicator is based on joint qualitative research by WWF and Tecnoma (Typsa Group). It indicates how aware local residents typically are of water-related issues due to national media coverage. The status of the river basin (e.g., scarcity and pollution) is taken into account, as well as the importance of water for livelihoods (e.g., food and shelter).	WWF & Tecnoma (TYPSA Group)
11.2 - Global Media Coverage (score)	3.00	This risk indicator is based on joint qualitative research by WWF and Tecnoma (Typsa Group). It indicates how aware people are of water-related issues due to global media coverage. Familiarity to and media coverage of the region and regional water-related disasters are taken into account.	WWF & Tecnoma (TYPSA Group)
11.2 - Global Media Coverage (rank)	37	This risk indicator is based on joint qualitative research by WWF and Tecnoma (Typsa Group). It indicates how aware people are of water-related issues due to global media coverage. Familiarity to and media coverage of the region and regional water-related disasters are taken into account.	WWF & Tecnoma (TYPSA Group)

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
12.1 - Conflict News Events (RepRisk) (score)	2.00	This risk indicator is based on 2018 data collected by RepRisk on counts and registers of documented negative incidents, criticism and controversies that can affect a company's reputational risk. These negative news events are labelled per country and industry class.	RepRisk & WWF (2019). Due diligence database on ESG and business conduct risks. RepRisk.
12.1 - Conflict News Events (RepRisk) (rank)	128	This risk indicator is based on 2018 data collected by RepRisk on counts and registers of documented negative incidents, criticism and controversies that can affect a company's reputational risk. These negative news events are labelled per country and industry class.	RepRisk & WWF (2019). Due diligence database on ESG and business conduct risks. RepRisk.
12.2 - Hydro-political Risk (score)	2.92	This risk indicator is based on the assessment of hydro-political risk by Farinosi et al. (2018). More specifically, it is based on the results of spatial modelling by Farinosi et al. (2018) that determined the main parameters affecting water cross-border conflicts and calculated the likelihood of hydro-political issues.	Farinosi, F., Giupponi, C., Reynaud, A., Ceccherini, G., Carmona-Moreno, C., De Roo, A., ... & Bidoglio, G. (2018). An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues. Global environmental change, 52, 286-313.
12.2 - Hydro-political Risk (rank)	54	This risk indicator is based on the assessment of hydro-political risk by Farinosi et al. (2018). More specifically, it is based on the results of spatial modelling by Farinosi et al. (2018) that determined the main parameters affecting water cross-border conflicts and calculated the likelihood of hydro-political issues.	Farinosi, F., Giupponi, C., Reynaud, A., Ceccherini, G., Carmona-Moreno, C., De Roo, A., ... & Bidoglio, G. (2018). An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues. Global environmental change, 52, 286-313.
Population, total (#)	32275687	Population, total	The World Bank 2018, Data , hompage accessed 20/04/2018
GDP (current US$)	646438380560	GDP (current US$)	The World Bank 2018, Data , hompage accessed 20/04/2018
EPI 2018 score (0-100)	57.47	Environmental Performance Index	
WGI -Voice and Accountability (0-100)	28.57	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132

Water Risk Filter

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
WGI -Political stability no violence (0-100)	3.94	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132
WGI - Government Effectiveness (0-100)	63.46	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132
WGI - Regulatory Quality (0-100)	55.77	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132
WGI - Rule of Law (0-100)	67.79	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132
WGI - Control of Corruption (0-100)	62.98	Water Governance Indicator	Kaufmann, Daniel and Kraay, Aart and Mastruzzi, Massimo, The Worldwide Governance Indicators: Methodology and Analytical Issues (September 2010). World Bank Policy Research Working Paper No. 5430. Available at SSRN: https://ssrn.com/abstract=1682132

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
WRI BWS all industries (0-5)	4.99	WRI Baseline Water Stress (BWS)	Gassert, F., P. Reig, T. Luo, and A. Maddocks. 2013. "Aqueduct country and river basin rankings: a weighted aggregation of spatially distinct hydrological indicators." Working paper. Washington, DC: World Resources Institute, December 2013. Available online at http://wri.org/publication/aqueduct-country-river-basin-rankings.
WRI BWS Ranking (1=very high)	17	WRI Baseline Water Stress (BWS)	Gassert, F., P. Reig, T. Luo, and A. Maddocks. 2013. "Aqueduct country and river basin rankings: a weighted aggregation of spatially distinct hydrological indicators." Working paper. Washington, DC: World Resources Institute, December 2013. Available online at http://wri.org/publication/aqueduct-country-river-basin-rankings.
Baseline Water Stress (BWS) - 2020 BAU (1=very high)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2020 Optimistic (increasing rank describes lower risk)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2020 Pessimistic (increasing rank describes lower risk)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.

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Country Overview - Saudi Arabia

Indicator	Value	Description	Source
Baseline Water Stress (BWS) - 2030 BAU (increasing rank describes lower risk)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2030 Optimistic (increasing rank describes lower risk)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2030 Pessimistic (increasing rank describes lower risk)	7	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2040 BAU (increasing rank describes lower risk)	9	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2040 Optimistic (increasing rank describes lower risk)	10	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.
Baseline Water Stress (BWS) - 2040 Pessimistic (increasing rank describes lower risk)	9	WRI country ranking	Luo, T., R. Young, and P. Reig. 2015. "Aqueduct projected water stress rankings." Technical note. Washington, DC: World Resources Institute, August 215. Available online at http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings.

Water Risk Filter

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
Total water footprint of national consumption (m3/a/cap)	1849.30	WFN Water Footprint Data	Mekonnen, M.M. and Hoekstra, A.Y. (2011) National water footprint accounts: The green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands.http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol1.pdf
Ratio external / total water footprint (%)	66.06	WFN Water Footprint Data	Mekonnen, M.M. and Hoekstra, A.Y. (2011) National water footprint accounts: The green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands.http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol1.pdf
Area equipped for full control irrigation: total (1000 ha)	1620.00	Aquastat - Irrigation	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Area equipped for irrigation: total (1000 ha)	1620.00	Aquastat - Irrigation	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
% of the area equipped for irrigation actually irrigated (%)	100.00	Aquastat - Irrigation	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Electricity production from hydroelectric sources (% of total)	0.00	World Development Indicators	The World Bank 2018, Data , hompage accessed 20/04/2018
Total internal renewable water resources (IRWR) (10^9 m3/year)	2.40	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Total internal renewable water resources (IRWR) (10^9 m3/year)	0.00	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Water resources: total external renewable (10^9 m3/year)	2.40	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13

Water Risk Filter

Country Overview - Saudi Arabia

Indicator	Value	Description	Source
Total renewable water resources (10^9 m3/year)	2.40	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Dependency ratio (%)	0.00	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Total renewable water resources per capita (m3/inhab/year)	76.09	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
World happiness [0-8]	6.37	WorldHappinessReport.org	World Happiness Report, homepage accessed 20/04/2018

Country Aspects

1. PHYSICAL ASPECTS

1.1. WATER RESOURCES

1.1.1. WATER RESOURCES

Heavy rainfall in Saudi Arabia sometimes results in short flash floods. Riverbeds are dry the rest of the time. Part of the surface runoff percolates through the sedimentary layers in the valleys and recharges the groundwater, while some is lost through evaporation. The largest quantity of runoff occurs in the western region. This represents 60 per cent of the total runoff, although it covers only 10 per cent of the total area of the country. The remaining 40 per cent of the total runoff occurs in the far south of the western coast (Tahama), which only covers 2 per cent of the total area of the country.

Total renewable surface water resources have been estimated at 2.2km3/yr, most of which infiltrates to recharge the aquifers. Total renewable groundwater resources are estimated at 2.2km3/yr, and the overlap at 2km3/yr, which brings total internal renewable water resources to 2.4km3/yr. Total groundwater reserves (including fossil groundwater) have been estimated at about 500km3, of which 340km3 is probably abstractable at an acceptable cost in view of the economic conditions of the country.

Groundwater is stored in six major consolidated sedimentary old-age aquifers located in the eastern and central parts of the country. This fossil groundwater, formed some 20,000 years ago, is confined in sand and limestone formations about 300m thick and 150-1,500m deep. Fossil aquifers contain large quantities of water trapped in fissures. For example, the Saq aquifer in the eastern part of the country extends over 1,200km northwards.

However, all these aquifers are poorly recharged (water entered them thousands of years ago), yet continuously “mined”. The natural recharge of the aquifers is only about 3.5 million m3/day, or 1.28km3/yr. These resources are precious as they are not the product of an ongoing hydrological cycle. According to the Water Atlas of Saudi Arabia, these resources are estimated at 253.2km3 as proven reserves, while their probable and possible reserves are 405 and 705km3 respectively.

In a similar study the Ministry of Planning showed that the reserves amount to 338km3 with secondary reserves reaching 500km3 (probable). Estimates made by the Scientific Research Institute’s Water Resources Division at Dahran city of 36,000km3 are more than 70 times higher than the other estimates. However, they estimated 870km3 as being economically abstractable which is somewhat closer to the above figures. Furthermore, they stressed that with technological advances more could be used. An engineering firm, the Saudi Arabia Engineering Consult, gave an estimate of about 2,175km3. These studies may indicate that the estimates of the ministries are very conservative (Al-Mogrin, 2001). In total, an estimated 394 million m3/yr flows from aquifers from Saudi Arabia to Jordan (180 million m3), Bahrain (112 million m3), Iraq (80 million m3), Kuwait (20 million m3) and Qatar (2 million m3).

In 2004, there were approximately 223 dams of various sizes for flood control, groundwater recharge and irrigation, with a collective storage capacity of 835.6 million m3. The King Fahd Dam in Bisha in the southwest, with a capacity of 325 million m3, was built in 1997 and there are plans to build another 17 dams.

Saudi Arabia is the largest producer of desalinated water from the sea. In 2004 there were 30 desalination and power plants. There were 24 plants on the west coast and six on the east coast. In 2006, 1.03km3 of desalinated water was produced. The water produced is used for municipal purposes. The quantities produced cover some 48 per cent of municipal uses. In fact, the desalinated water produced is sometimes exported to distant cities. For instance, in 2004 some 528 million m3 was produced on the west coast, of which over 50 per cent was exported to the city of Jiddah. Around 536 million m3 was produced on the east coast, of which over 65 per cent was exported to Riyadh, in the centre of the country 400km from the sea. The total length of pipelines used for the transmission of desalinated water is about 4,156km. The capacity of desalinated water reservoirs amounts to 9.38 million m3.

In 2002, total treated wastewater reached almost 548 million m3, of which 123 million m3 was reused. In 2003, 70 sewage treatment plants were in operation. The use of treated wastewater is still limited at present (166 million m3 in 2006), but it represents a potentially important source of water for irrigation and other uses.

According to Aseer (2003), water resources in the Kingdom of Saudi Arabia can be categorized as follows: surface water, groundwater, desalinated seawater and treated wastewater. In 1995-96 surface water and renewable groundwater made up an estimated 13.8 per cent of all water used. Non-renewable groundwater comprised 81.5 per cent, while desalinated seawater comprised 3.8 per cent and reclaimed municipal wastewater only 0.8 per cent.

Saudi Arabia is located within an extremely arid region where the average rainfall is low and surface water is very limited. There are no perennial rivers. However, low rainfall quantities across the Kingdom create limited surface runoff. This surface water is the result of rain that floods and flows in the wadis for short durations. The quantity of the annual runoff in the Kingdom is estimated to be about 2,230 million m3, with an average annual rainfall ranging from 25-150mm (Aseer, 2003).

Most of the runoff occurs in the southwestern region of the Kingdom (about 1,450m3), which includes the western coastal area that is linked to the Sarawat mountain ranges. Although the escarpment represents less than 10 per cent of the area of the Kingdom, more than 60 per cent of water flows are found in this region. The surface water flows east of the Sarawat Mountains or toward the west to the low inland regions. The basins of Wadi Bisha and Wadi Najran are most likely to have major water flows. Some other important wadis are Wadi Rumah in the central region, Wadi Al Sarhan in the northern region, and Wadi Khulais and Wadi Fatima in the western region (Aseer, 2003).

Water is found in the sediment of the above-mentioned wadis. There are 90 wadis in Tihama Plain, of which 36 have special importance. In the past, these wadi sediments were a major water source as the volume of water derived from them is quite large. The mean flows in northern Tihamna during the last 10 years amounted to 310m3 annually; most of it draining to the sea. This has necessitated the construction of several dams on carefully selected sites in the wadi courses. This aimed to use water flows in agricultural development or recharging the underground aquifers. One hundred and eighty four dams of different shapes and sizes have been built, with a total storage capacity of 774m3. These dams were constructed for groundwater recharge and flood control purposes. It is worth noting that the available surface water is an important resource for the Kingdom due to its good quality (Aseer, 2003).

Groundwater in the Kingdom can be classified into two categories: groundwater stored in sediments and in weathered and fractured rocks; and groundwater in sedimentary rock. Water quality and quantity depends on several factors, such as the nature and thickness of the sediment and the frequency and intensity of rainfall. However, this type of water commonly occurs in different parts of the Kingdom, mostly in the western parts of the Arabian Shield. It occurs mainly in metamorphic igneous rocks, as runoff water seeps through the wadi sediments to aquifers. The area containing groundwater in sedimentary rocks is about 1.5 million km2, with a thickness of about 5,500m. It includes aquifers, some of which contain huge quantities of water. Water quantity, quality and depth differ from place to place (Aseer, 2003).

1.1.2. WATER USE

It is estimated that in 2006 total water withdrawal was 23.7km3, an increase of 40 per cent compared to 1992. Withdrawal was shared between the sectors as follows: agriculture 88 per cent; municipal 9 per cent; and industry 3 per cent. The boom in desert agriculture tripled the volume of water used for irrigation from about 6.8km3 in 1980 to about 21km3 in 2006. Total surface water and groundwater withdrawal represented 943 per cent of the total renewable water resources. Groundwater resources of Saudi Arabia are being depleted at a very fast rate. Most water withdrawn comes from fossil, deep aquifers and some predictions suggest that these resources may not last more than about 25 years. The quality of the abstracted water is also likely to deteriorate with time because of the flow of low quality water in the same aquifers toward the core of the depression at the point of use. In 2003 there were 5,661 government wells assigned for municipal purposes and 106,370 multipurpose private wells. Treated wastewater is used to irrigate non-edible crops, for landscape irrigation and for industrial cooling, while desalinated water is used for municipal purposes.

According to Aseer (2003), since its establishment in 1974, the Saline Water Conversion Corporation (SWCC) has constructed 25 plants with a daily water output of about 2 million m3 of desalinated water. The major desalination plants are located in 15 different sites, 12 of which produce 0.793m3 per day. Other sites, located on the Arabian Gulf coast, produce 1.145m3 per day. Some plants are confined to seawater desalination, while others have the dual purpose of producing drinking water and generating electricity.

In spite of an acute water shortage in the Kingdom, treated wastewater is unfortunately being wasted. Currently, with the exception of 150m3 of treated wastewater, all reclaimed wastewater is discharged into the sea or wasted.

The Ministry of Agriculture and Water strongly encouraged reuse of treated wastewater with the passage of Royal Decree no. M/6 in 1999. Notably, 40,000m3 of treated wastewater are put to use daily in Riyadh for irrigation. The Riyadh refinery uses 20,000m3 per day for cooling purposes. In addition, there are projects currently being carried out to irrigate farms in Mazahmia, Druma, Jebilah and Al Oiynah. Feasibility studies are also being carried out for using this water in both Medina and Qassim. Treated wastewater is also currently used in many Saudi cities for landscaping. It should also be noted that Saudi Aramco is treating wastewater at Mubarraz Dhahran and Tanajeeb at a tertiary level for unrestricted irrigation. Other agencies were urged to develop their own wastewater treatment plants to use water in irrigating lawns or for afforestation (Aseer, 2003).

Due to the tremendous, positive response by Saudi citizens, the Ministry of Agriculture and Water, in cooperation with the Ministry of Municipal and Rural Affairs and wastewater authorities, has prepared a draft on national standards of treated wastewater in the Kingdom. The proposed regulations include standards for domestic and industrial wastewater and the levels of treatment required. The law pertaining to the use of treated wastewater has been ratified and its passage helps to encourage potential users of treated wastewater and to regulate its use (Aseer, 2003).

1.2. WATER QUALITY, ECOSYSTEMS AND HUMAN HEALTH

According to the Economic and Social Commission for Western Asia (ESCWA) (2004), in Saudi Arabia, responsibility for environmental issues is vested in the Ministerial Committee on Environment and its executive arm, the Environmental Monitoring and Protection Bureau. The Bureau is in charge of water quality issues, applying the environmental protection standards adopted in 1981 and amended in 1989. Those standards are divided into three parts: water guidelines, standards on direct withdrawal and guidelines for wastewater treatment before disposal to sewers. The Saudi Normative Standards Organization is responsible for drinking water standards, both tariffed and non-tariffed, while water and sanitation authorities are responsible for drinking water distribution and monitoring water in distribution systems to make sure that it is safe to drink.

2. GOVERNANCE ASPECTS

2.1. WATER INSTITUTIONS

In 2001, a Ministry of Water was created to contain part of the Ministry of Municipal and Rural Affairs and part of the former Ministry of Agriculture and Water. This new ministry was responsible for supervising the water sector, developing water-related policies and setting up mechanisms and

instruments aimed at managing the water resources and water services delivery in an efficient and sustainable way. In 2004, the Ministry of Water also became responsible for the electricity sector and was restructured as the Ministry of Water and Electricity (MOWE) to ensure optimum coordination between the development of water desalination and electricity production.
The water sector within the MOWE has two main programmes:
-Water resources development, which includes all activities related to geological and hydrological studies, wastewater reuse investigations, well drilling and dam construction, and the preparation of the national water plan;
-Drinking water supply, which includes the construction of drinking water supply networks to various towns and cities that do not have local water authorities or municipalities.
The Ministry of Agriculture (MOA) is responsible for the scheme's operation and maintenance programme, while on-farm water management is the farmers' responsibility. The ministry is responsible for issues affecting more than one farmer, such as irrigation networks, drainage and pest control.
In January 2005, the MOA created the General Administration of Irrigation Affairs (GAIA), following the creation of the MOWE. The GAIA is responsible for organizing, planning, monitoring, developing, operating and maintaining irrigation and drainage projects and programmes; applying modern systems; determining crop water requirements; and ensuring that irrigation water has no harmful effects on public health.
The National Irrigation Authority (NIA) started operating in 1982 in the province of Riyadh to reuse the largest amount of treated wastewater in Saudi Arabia, mainly for irrigation. This amounted to 33 per cent of total effluent treated annually. The NIA is responsible for the operation of the infrastructure, the monitoring of water reuse practices and the compliance of farmers with standards and guidelines. In 2004 it covered a total of 455 farms over an area of 174km2 (about 120km2 irrigated). The average distributed volume of wastewater is about 50 million m3 per year.
The Al-Hassa Irrigation and Drainage Authority is part of the MOA and is in charge of hydrological studies and data collection to improve the use of water for irrigation. It is also responsible for irrigation water conservation, estimation of crop water requirements, irrigation water distribution to the farms and the operation and maintenance of irrigation and drainage canal systems in the irrigation schemes managed by the MOA.
The irrigation and drainage project in Domat Al Jandal started in 1989. It covers a designated area of 16km2, serving about 2,000 farms in Al-Jouf in the northern part of the country.
The SWCC is responsible for the construction, operation and maintenance of desalination plants.
According to ESCWA (2004), in Saudi Arabia, the bodies in charge of drinking water and wastewater come under the authority of the MOWE, while desalination plants are the responsibility of the Ministry of Agriculture and Irrigation.
According to Aseer (2003), at present, the government implements its water policies, rules and regulations through the following ministries, organizations and agencies:
Ministry of Agriculture and Water
This ministry is responsible for planning and development of all water resources. It is a key organization in implementing most agricultural and water-related policies and programmes. such as irrigation and drainage, and support to small farmers. The ministry is also responsible for the licensing of all activities concerning agriculture, fisheries, forestry and the exploration and use of water resources (Aseer, 2003).
Al-Hassa Irrigation and Drainage AuthorityAl-Hassa Irrigation and Drainage Authority
The authority introduces modern technology, including the construction of aqueducts for the irrigation of extensive cultivated land in the Al-hassa Oasis (Aseer, 2003).The authority introduces modern technology, including the construction of aqueducts for the irrigation of extensive cultivated land in the Al-hassa Oasis (Aseer, 2003).
MunicipalitiesMunicipalities
In addition to providing drinking water, municipalities are also responsible for regularly collecting and safely disposing of all forms of waste such as sewage and trash. Reuse of treated wastewater for irrigation of plant nurseries and public greenery is practised. The municipalities' community sanitation control measures also cover a wide range of activities (Aseer, 2003).In addition to providing drinking water, municipalities are also responsible for regularly collecting and safely disposing of all forms of waste such as sewage and trash. Reuse of treated wastewater for irrigation of plant nurseries and public greenery is practised. The municipalities' community sanitation control measures also cover a wide range of activities (Aseer, 2003).
Ministry of Municipal mid Rural Affairs (MOMRA)Ministry of Municipal mid Rural Affairs (MOMRA)
Water and wastewater services are handled by MOMRA on a regular basis through six Water and Sewage Boards, which are staffed by MOMRA and chaired by a responsible governor or deputy (Aseer, 2003).Water and wastewater services are handled by MOMRA on a regular basis through six Water and Sewage Boards, which are staffed by MOMRA and chaired by a responsible governor or deputy (Aseer, 2003).
Meteorology and Environmental Protection Administration (MEPA)Meteorology and Environmental Protection Administration (MEPA)
MEPA is responsible for the following: environmental surveys and pollution assessment; establishment of environmental standards and regulations (relating to water and land pollution); disposal of liquid and gaseous waste, use and disposal of all chemical, pesticide and radioactive materials; and control of pollution. It also makes recommendations on response to emergency situations; keeps abreast of environmental developments on the international scene; and they prepares and issues climatological, environmental and meteorological analyses, forecasts and bulletins, in real and non-real time format (Aseer, 2003).MEPA is responsible for the following: environmental surveys and pollution assessment; establishment of environmental standards and regulations (relating to water and land pollution); disposal of liquid and gaseous waste, use and disposal of all chemical, pesticide and radioactive materials; and control of pollution. It also makes recommendations on response to emergency situations; keeps abreast of environmental developments on the international scene; and they prepares and issues climatological, environmental and meteorological analyses, forecasts and bulletins, in real and non-real time format (Aseer, 2003).

Royal Commission for Jubail and YanbuRoyal Commission for Jubail and Yanbu
Through a memorandum of understanding with MEPA, the Royal Commission was delegated to accomplish all environmental management functions in its area of jurisdiction. It requires regular self-monitoring of pollution levels by individual enterprises and continuous monitoring of ambient air, water and noise levels (Aseer, 2003).Through a memorandum of understanding with MEPA, the Royal Commission was delegated to accomplish all environmental management functions in its area of jurisdiction. It requires regular self-monitoring of pollution levels by individual enterprises and continuous monitoring of ambient air, water and noise levels (Aseer, 2003).
Saudi Arabian Standards Organization (SASO)Saudi Arabian Standards Organization (SASO)
This national organization is responsible for quality control. It prepares and publishes performance and product standards such as standards for bottled and non-bottled water (Aseer, 2003).This national organization is responsible for quality control. It prepares and publishes performance and product standards such as standards for bottled and non-bottled water (Aseer, 2003).
Due to the government's awareness of the scarcity of water, the MOA implemented several measures to encourage farmers to apply irrigation water saving techniques. Furthermore, some of the subsidies and support programmes that contributed to the depletion of groundwater resources in agriculture have been discontinued or revised. A collaborative programme has been initiated with the World Bank to provide technical assistance in reorganizing the water sector as a whole.Due to the government's awareness of the scarcity of water, the MOA implemented several measures to encourage farmers to apply irrigation water saving techniques. Furthermore, some of the subsidies and support programmes that contributed to the depletion of groundwater resources in agriculture have been discontinued or revised. A collaborative programme has been initiated with the World Bank to provide technical assistance in reorganizing the water sector as a whole.
The MOA provides technical training courses and workshops on irrigation water management for its employees as well as others in different public and private sectors. Some courses are coordinated with international organizations, such as the Food and Agriculture Organization of the United Nations (FAO). Unfortunately the MOA lacks sound and effective extension services, has no strategy for capacity building and has weak information management systems. Furthermore, no water use associations exist in the country.The MOA provides technical training courses and workshops on irrigation water management for its employees as well as others in different public and private sectors. Some courses are coordinated with international organizations, such as the Food and Agriculture Organization of the United Nations (FAO). Unfortunately the MOA lacks sound and effective extension services, has no strategy for capacity building and has weak information management systems. Furthermore, no water use associations exist in the country.
An academic association, the Saudi Water Science Society, was recently created, hosted by the King Fahd University of Petroleum and Minerals. Its main purpose is to provide a union of experts, scientists and businessmen, all of whom have an interest in water concerns and issues in the country.An academic association, the Saudi Water Science Society, was recently created, hosted by the King Fahd University of Petroleum and Minerals. Its main purpose is to provide a union of experts, scientists and businessmen, all of whom have an interest in water concerns and issues in the country.
According to ESCWA (2004), in the Kingdom of Saudi Arabia, water resource planning has been based on policies and strategies embedded in successive five-year development plans. Over the past two decades, the emphasis has been on increasing quantities of desalinated water to meet domestic needs, evaluating deep groundwater reserves, implementing groundwater recharge programmes, flood control, building water supply and wastewater disposal systems, and reusing treated water. However, the most recent five-year plan features a concern to achieve a balance between supply and demand, with emphasis on water conservation through more efficient irrigation, reduced demand from the agricultural sector, groundwater resource monitoring and preservation, and increasing supply by means of seawater desalination.According to ESCWA (2004), in the Kingdom of Saudi Arabia, water resource planning has been based on policies and strategies embedded in successive five-year development plans. Over the past two decades, the emphasis has been on increasing quantities of desalinated water to meet domestic needs, evaluating deep groundwater reserves, implementing groundwater recharge programmes, flood control, building water supply and wastewater disposal systems, and reusing treated water. However, the most recent five-year plan features a concern to achieve a balance between supply and demand, with emphasis on water conservation through more efficient irrigation, reduced demand from the agricultural sector, groundwater resource monitoring and preservation, and increasing supply by means of seawater desalination.
Some ESCWA countries, including Oman until very recently, and currently Saudi Arabia, have adopted this institutional model (water resource management as the responsibility of a separate ministry), separating water resource management from water-using sectors. A separate ministry is put in charge of water resource planning and management; that ministry thus serves all user sectors but is independent of them. This arrangement avoids the conflict-of-interest situation that may arise when the task of managing water resources is entrusted to a water-using sector. However, the ministry may find that it does not enjoy much influence with the public or with other government bodies (compared to executive ministries such as the Ministry of Agriculture and Irrigation), since it does not implement water utilization projects. This detracts from its authority, especially in rural areas, as people expect the state to launch such projects. A separate ministry may also find that it has to compete with sectoral ministries, and this will have an adverse impact on its relations with high-level bodies such as the Council of Ministers or parliament. The effect may be to weaken its policy coordination, oversight and enforcement role. Consequently, a separate Ministry may prove ineffectual in exercising its official functions of allocating water and bringing water resource management policy under the umbrella of economic development policy. The ESCWA region has experimented with a separate ministry for water resources only to a limited extent. As noted above, the idea was tried and abandoned in Oman, and has recently been introduced in Saudi Arabia (ESCWA, 2004).Some ESCWA countries, including Oman until very recently, and currently Saudi Arabia, have adopted this institutional model (water resource

management as the responsibility of a separate ministry), separating water resource management from water-using sectors. A separate ministry is put in charge of water resource planning and management; that ministry thus serves all user sectors but is independent of them. This arrangement avoids the conflict-of-interest situation that may arise when the task of managing water resources is entrusted to a water-using sector. However, the ministry may find that it does not enjoy much influence with the public or with other government bodies (compared to executive ministries such as the Ministry of Agriculture and Irrigation), since it does not implement water utilization projects. This detracts from its authority, especially in rural areas, as people expect the state to launch such projects. A separate ministry may also find that it has to compete with sectoral ministries, and this will have an adverse impact on its relations with high-level bodies such as the Council of Ministers or parliament. The effect may be to weaken its policy coordination, oversight and enforcement role. Consequently, a separate Ministry may prove ineffectual in exercising its official functions of allocating water and bringing water resource management policy under the umbrella of economic development policy. The ESCWA region has experimented with a separate ministry for water resources only to a limited extent. As noted above, the idea was tried and abandoned in Oman, and has recently been introduced in Saudi Arabia (ESCWA, 2004).
Since the creation of the MOWE, various water laws are under revision and reformulation to assure institutional compatibility with the new institutional structure. At the same time, the MOA is reviewing agricultural policy. Currently there are still grey areas with overlapping responsibilities regarding irrigation and the control and implementation of water reuse for irrigation.Since the creation of the MOWE, various water laws are under revision and reformulation to assure institutional compatibility with the new institutional structure. At the same time, the MOA is reviewing agricultural policy. Currently there are still grey areas with overlapping responsibilities regarding irrigation and the control and implementation of water reuse for irrigation.
According to Aseer (2003), the Saudi Arabian government has concurrently implemented an integrated water policy through its ministries, organizations and agencies to better manage the Kingdom's water resources. This policy includes:According to Aseer (2003), the Saudi Arabian government has concurrently implemented an integrated water policy through its ministries, organizations and agencies to better manage the Kingdom's water resources. This policy includes:
•Require authorization of digging of wells by obtaining a licence from the Ministry of Agriculture and Water;•Require authorization of digging of wells by obtaining a licence from the Ministry of Agriculture and Water;
•Encourage the construction of specialized projects and plants in the main cities of the Kingdom to pump the treated water through pipeline networks to farms in villages and rural areas;•Encourage the construction of specialized projects and plants in the main cities of the Kingdom to pump the treated water through pipeline networks to farms in villages and rural areas;
•Adopt the strategy of promoting agricultural production diversification and water-saving crops;•Adopt the strategy of promoting agricultural production diversification and water-saving crops;
•Use advanced irrigation techniques such as drip and sprinkler system to improve irrigation efficiency and reduce water use;•Use advanced irrigation techniques such as drip and sprinkler system to improve irrigation efficiency and reduce water use;
•Move some of the fodder and cereals areas from high crop zones to lower water requirement areas;•Move some of the fodder and cereals areas from high crop zones to lower water requirement areas;
•Establish several pricing categories for penalizing subscribers in a way that leads all water users to conserve water;•Establish several pricing categories for penalizing subscribers in a way that leads all water users to conserve water;
•Adopt nationwide campaigns to educate and spread public awareness about water conservation;•Adopt nationwide campaigns to educate and spread public awareness about water conservation;
•Encourage scientific research aimed at finding additional uses for wastewater.•Encourage scientific research aimed at finding additional uses for wastewater.
The following rules and regulations are being applied (Aseer, 2003):The following rules and regulations are being applied (Aseer, 2003):
•Destruction of wells drilled in violation of established regulations has been undertaken. A large number of wells have been buried in different parts of the Kingdom;•Destruction of wells drilled in violation of established regulations has been undertaken. A large number of wells have been buried in different parts of the Kingdom;
•A network programme for monitoring underground water has been established to check water levels and movements throughout the Kingdom;•A network programme for monitoring underground water has been established to check water levels and movements throughout the Kingdom;
•Fines and penalties, including imprisonment, are being imposed for polluting water or other environmental resources by disposal of waste oil, batteries, industrial or cosmopolitan waste, hazardous waste, or other pollutants;•Fines and penalties, including imprisonment, are being imposed for polluting water or other environmental resources by disposal of waste oil, batteries, industrial or cosmopolitan waste, hazardous waste, or other pollutants;
•Organizations or companies that own housing complexes have been instructed to use drainage water or teamed wastewater for watering their lawns.•Organizations or companies that own housing complexes have been instructed to use drainage water or teamed wastewater for watering their lawns.
The following recommendations are made (Aseer, 2003):The following recommendations are made (Aseer, 2003):
•Approximately 30 per cent of all generated municipal wastewater is collected and treated. There is an immediate need to rapidly expand sewage systems and treatment capacity to include all generated wastewater. This is important from both environmental and public health standpoints. It is also economically beneficial when considering the costs of the damage caused by a rising groundwater table.•Approximately 30 per cent of all generated municipal wastewater is collected and treated. There is an immediate need to rapidly expand sewage systems and treatment

capacity to include all generated wastewater. This is important from both environmental and public health standpoints. It is also economically beneficial when considering the costs of the damage caused by a rising groundwater table.

•It is estimated that only 8 per cent of all generated municipal wastewater is accounted for in direct reuse applications. Reuse of treated wastewater in agricultural and landscape irrigation should be given top priority in the Kingdom. This is an important conservation measure. Reclaimed wastewater can supplement the already declining water supply that has to be satisfied through costly seawater desalination or depletion of nonrenewable groundwater.•It is estimated that only 8 per cent of all generated municipal wastewater is accounted for in direct reuse applications. Reuse of treated wastewater in agricultural and landscape irrigation should be given top priority in the Kingdom. This is an important conservation measure. Reclaimed wastewater can supplement the already declining water supply that has to be satisfied through costly seawater desalination or depletion of nonrenewable groundwater.

•The absence of guidelines for treatment plant selection, and treatment objectives specific to Saudi Arabian requirements, has led to the construction of treatment plants with diverse technologies and objectives. Many of these plants, however, do not give attention to local needs, technical capabilities and quality control measures. It is important at this stage to learn from experiences at existing plants and establish clear and enforceable guidelines to be followed for plant selection and design, based on local needs and specified national goals.•The absence of guidelines for treatment plant selection, and treatment objectives specific to Saudi Arabian requirements, has led to the construction of treatment plants with diverse technologies and objectives. Many of these plants, however, do not give attention to local needs, technical capabilities and quality control measures. It is important at this stage to learn from experiences at existing plants and establish clear and enforceable guidelines to be followed for plant selection and design, based on local needs and specified national goals.

•Only a few of the currently operating treatment plants have effluents suitable for actual disposal practice or reuse options. This is because the remaining plants either have operation and maintenance problems or because the treatment scheme is not suitable for the application. Mismanagement of treatment plants has to be stopped and effluents have to be disposed of and/or reused in a way compatible with effluent quality.•Only a few of the currently operating treatment plants have effluents suitable for actual disposal practice or reuse options. This is because the remaining plants either have operation and maintenance problems or because the treatment scheme is not suitable for the application. Mismanagement of treatment plants has to be stopped and effluents have to be disposed of and/or reused in a way compatible with effluent quality.

<h2>2.2.WATER MANAGEMENT2.2.WATER MANAGEMENT<h2>2.3.WATER POLICY AND LEGAL FRAMEWORK2.3.WATER POLICY AND LEGAL FRAMEWORK

3. GEOPOLITICAL ASPECTS

According to Marina (2010), the Arab region is one of the most water-scarce regions in the world. Of all renewable water resources in the region, two-thirds originate from sources outside the region (El-Quosy, 2009).

Surface and underground water resources are shared among countries within the region and with countries from outside the region. Three rivers, namely, the Nile, the Tigris and the Euphrates, account for the majority of the region's surface water. All three rivers are shared among more than two riparian countries. Other shared surface waters include the Jordan River, the Nahr Al-Kabir and the Orontes (Marina, 2010).

The Arab region also relies heavily on groundwater which is found in a number of shared aquifers such as the basalt aquifer shared by Jordan and Syria, the Palaeogene aquifer shared by Oman and the United Arab Emirates, the Disi sandstone aquifer shared by Jordan and Saudi Arabia, and the Nubian Sandstone Aquifer System shared by Chad, Egypt, Libya and Sudan. As with surface water, the major aquifers in the region are shared between two or more countries. In fact, the majority of territorially contiguous states in the Middle East and North Africa share both renewable and non-renewable groundwater aquifers (Marina, 2010).

4. SOURCES

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