Water Risk Filter

Country Overview - Lebanon

Water Indicators

Indicator	Value	Description	Source
Overall Basin Risk (score)	3.28	Overall Basin Risk (score)	
Overall Basin Risk (rank)	8	Overall Basin Risk (rank)	
Physical risk (score)	3.76	Physical risk (score)	
Physical risk (rank)	3	Physical risk (rank)	
Regulatory risk (score)	2.99	Regulatory risk (score)	
Regulatory risk (rank)	68	Regulatory risk (rank)	
Reputation risk (score)	2.11	Reputation risk (score)	
Reputation risk (rank)	178	Reputation risk (rank)	
1. Quantity - Scarcity (score)	3.93	1. Quantity - Scarcity (score)	
1. Quantity - Scarcity (rank)	13	1. Quantity - Scarcity (rank)	
2. Quantity - Flooding (score)	3.83	2. Quantity - Flooding (score)	
2. Quantity - Flooding (rank)	51	2. Quantity - Flooding (rank)	
3. Quality (score)	4.01	3. Quality (score)	
3. Quality (rank)	23	3. Quality (rank)	
4. Ecosystem Service Status (score)	2.75	4. Ecosystem Service Status (score)	
4. Ecosystem Service Status (rank)	66	4. Ecosystem Service Status (rank)	
5. Enabling Environment (Policy & Laws) (score)	3.35	5. Enabling Environment (Policy & Laws) (score)	
5. Enabling Environment (Policy & Laws) (rank)	38	5. Enabling Environment (Policy & Laws) (rank)	
6. Institutions and Governance (score)	3.25	6. Institutions and Governance (score)	
6. Institutions and Governance (rank)	66	6. Institutions and Governance (rank)	
7. Management Instruments (score)	3.00	7. Management Instruments (score)	
7. Management Instruments (rank)	79	7. Management Instruments (rank)	
8 - Infrastructure & Finance (score)	1.75	8 - Infrastructure & Finance (score)	
8 - Infrastructure & Finance (rank)	107	8 - Infrastructure & Finance (rank)	
9. Cultural Diversity (score)	1.00	9. Cultural importance (score)	
9. Cultural Diversity (rank)	123	9. Cultural importance (rank)	
10. Biodiversity Importance (score)	3.00	10. Biodiversity importance (score)	

Indicator	Value	Description	Source
10. Biodiversity Importance (rank)	123	10. Biodiversity importance (rank)	
11. Media Scrutiny (score)	2.00	11. Media Scrutiny (score)	
11. Media Scrutiny (rank)	186	11. Media Scrutiny (rank)	
12. Conflict (score)	2.53	12. Conflict (score)	
12. Conflict (rank)	86	12. Conflict (rank)	
1.0 - Aridity (score)	1.39	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)	86	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)	4.00	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)	3	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)	5.00	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)	1	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)	3.56	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)	54	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)	4.00	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)	2	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.

Indicator	Value	Description	Source
1.5 - Drought Frequency Probability (score)	4.13	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)	32	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)	5.00	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)	2	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)	3.98	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)	44	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)	1.00	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). 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)	188	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)	4.01	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)	23	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)	3.28	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)	42	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)	153	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)	4.00	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)	28	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)	8	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)	3.00	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)	44	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)	48	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)	4.00	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)	18	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)	3.00	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)	59	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)	2.00	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)	113	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)	3.00	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)	26	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)	29	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)	3.00	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)	119	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)	2.00	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)	70	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.

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Indicator	Value	Description	Source
8.2 - Access to Sanitation (rank)	119	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)	4.00	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)	11	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)	123	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)	4.00	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)	73	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)	2.00	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)	152	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)	2.00	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)	186	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)	2.00	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)	81	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)

Indicator	Value	Description	Source
12.1 - Conflict News Events (RepRisk) (score)	3.00	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)	61	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)	2.05	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)	118	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 (#)	6006668	Population, total	The World Bank 2018, Data , hompage accessed 20/04/2018
GDP (current US$)	49598825982	GDP (current US$)	The World Bank 2018, Data , hompage accessed 20/04/2018
EPI 2018 score (0-100)	61.08	Environmental Performance Index	
WGI -Voice and Accountability (0-100)	8.10	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

Indicator	Value	Description	Source
WGI -Political stability no violence (0-100)	31.53	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)	35.58	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)	40.87	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)	18.75	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)	13.94	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

Indicator	Value	Description	Source
WRI BWS all industries (0-5)	4.54	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)	28	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)	16	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)	16	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)	16	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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Indicator	Value	Description	Source
Baseline Water Stress (BWS) - 2030 BAU (increasing rank describes lower risk)	12	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)	14	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)	12	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)	11	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)	11	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)	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.

Country Overview - Lebanon

Indicator	Value	Description	Source
Total water footprint of national consumption (m3/a/cap)	2111.54	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 (%)	72.89	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)	104.00	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)	104.00	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 (%)	86.54	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)	1.08	World Development Indicators	The World Bank 2018, Data , hompage accessed 20/04/2018
Total internal renewable water resources (IRWR) (10^9 m3/year)	4.80	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)	-0.30	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)	4.80	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13

Country Overview - Lebanon

Indicator	Value	Description	Source
Total renewable water resources (10^9 m3/year)	4.50	Aquastat - Water Ressources	FAO. 2016. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). Website accessed on 2018/04/13
Dependency ratio (%)	0.79	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)	769.60	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]	5.20	WorldHappinessReport.org	World Happiness Report, homepage accessed 20/04/2018

Country Aspects

1. PHYSICAL ASPECTS

1.1. WATER RESOURCES

1.1.1. WATER RESOURCES

While Lebanon is in a relatively favourable position as far as rainfall and water resources are concerned, constraints for development consist in the limited availability of water during the seven dry summer months due to the very low water storage capacity, the difficulty of capturing the water close to the sea, and the shortcomings of the existing water delivery systems and networks.

The total length of streams in Lebanon is 730km, mainly on the western side of the mountains which have steep slopes. Annual internal renewable water resources are estimated at about 4.8km3. Annual surface runoff is around 4.1km3 and groundwater recharge 3.2km3, of which 2.5km3 constitutes the base flow of the rivers. About 1km3 of this flow comes from over 2,000 springs with an average unit yield of about 10–15 l/s, sustaining a perennial flow for 17 of the total of around 40 major streams in the country.

The annual net exploitable surface water and groundwater resources, water that Lebanon can technically and economically recover during average rainfall years, are estimated at 2.080 km3, consisting of 1.580 km3 of surface water and 0.500 km3 of groundwater.

In total, there are about 40 major streams in Lebanon and, based on the hydrographic system, the country can be divided into five regions:

-the Asi-Orontes basin in the north; the Asi-Orontes River flows into the Syrian Arab Republic in the northeast of the country;

-the Hasbani basin in the southeast; the Hasbani River, which flows into Israel in the southeast of the country, is a tributary of the Jordan river;

-the Litani basin in the east and south; the Litani River reaches the sea in the southwest of the country;

-all the remaining major coastal river basins - the northern El Kebir river basin is shared with the Syrian Arab Republic, the river itself forming part of the border between the two countries before flowing into the sea; and

-all the small, scattered and isolated sub-catchments remaining in between, with no noticeable surface stream flow, such as the endorheic catchments and isolated coastal pockets.

The first three river basins cover about 45 per cent of the country. The Asi-Orontes and Hasbani rivers are transboundary rivers, while the Litani River flows entirely within Lebanon. With a total length of 170km it is the longest river in Lebanon. Its catchment area is about 2,180 km2, equal to some 20 per cent of the total area of the country. Average annual water flowing in the Litani River is 475 million m3. In the coastal regions, there are about 12 perennial rivers originating in the western slopes of the mountain ranges and flowing from east to west to the sea. The coastal rivers have relatively small catchments (200km2 on average) and small courses (more than 50 km). The major replenishment of rivers in Lebanon comes from precipitation, as well as from snowmelt and springs. However, a drastic decrease in the river flow has been recorded in the last three decades.

There are eight major aquifers, with a total estimated volume of 1,360 million m3. Exploitable groundwater ranges from 400 to 1,000 million m3 [Samad, 2003]. The presence of fissures and fractures encourages snowmelt and rainwater to percolate and infiltrate deep into the ground and feed these aquifers. Water may reappear at lower elevations as springs that flow into rivers. Springs are commonly found in Lebanon because of the highly fractured geologic rocks, and because of the existing inter-bed rock formation of differing permeability, which is a feature of the whole country. In total, there are about 2,000 major springs and many other minor springs in Lebanon, generating an estimated flow of 1,150 million m3/year. Other springs are commonly found along the coast or in the submarine area. They are also called “non-conventional” springs because it is more or less impossible to capture their water before it flows into the sea.

Since Lebanon is at a higher elevation than its neighbours it has practically no incoming surface water flow. The flow of 76 million m3/year of the El Kebir River on the border between Lebanon and the Syrian Arab Republic is thought to be generated by the 707km2 bordering Syrian catchment areas. There might also be some groundwater inflow from these areas, but no figures on quantities are available.

Total surface water outflow is estimated at 735 million m3/year, of which 160 million m3 flow to the sea. Surface water outflow to the Syrian Arab Republic is estimated at 415 million m3 through the Asi-Orontes River. Surface water flow into northern Israel from the Hasbani/Wazani complex is estimated at 160 million m3/year.

The transboundary Mount Hermon aquifer contributes to the discharges of the Banias springs in the Golan and the Dan springs in Israel. The total groundwater outflow is estimated at about 1,020 million m3/year. Of this total, 740 million m3 is estimated to flow to the sea, 150 million m3 to Israel (Lake Hulah) and 130 million m3 to the Syrian Arab Republic (Dan Springs).

The geological conditions make construction of storage dams difficult. The largest artificial lake in Lebanon is located in the southern part of the fertile Bekaa valley on the upper Litani River, known as the Qaraoun reservoir. Constructed in the 1960s, it has a total capacity of about 220 million m3 and effective storage of 160 million m3 (60 million as the inter-annual reserve). It supplies in turn three hydroelectric plants generating about 7 to 10 per cent (about 190MW) of Lebanon’s total annual power needs. Moreover, the Qaraoun reservoir potentially provides every year a total of 140 million m3 for irrigation purposes (110 for south Lebanon and 30 for Bekaa), and 20 million m3 for domestic purposes to the south. On the other hand, the Green Plan (GP) (which is a public authority established in 1963 for the development of water reservoirs), the private sector and NGOs have already developed hundreds of small earth and concrete storage ponds, with a maximum capacity per unit of 0.2 million m3. During the period 1964–1992 the GP's activities led to a total of 3.5 million m3 earth ponds and 0.35 million m3 concrete ponds. The Litani River Authority implemented three hillside stock ponds in the early 1970s, for a total storage capacity of about 1.8 million m3. The Bisri dam on the Awali River is currently in the final design stage; it will have a storage capacity of 128 million m3 and is intended mainly for supplying water to Greater Beirut. The Khardaleh dam on the middle reach of the Litani River, with the same planned storage capacity of 128 million m3, has been put on hold at the preliminary design stage because of the prevailing adverse security situation in the southern border region. In 2007, a new artificial reservoir and dam, named Shabrouh, was inaugurated with a storage capacity of 8 million m3. It is located near the ski resort town of Faraya and provides water for domestic and irrigation purposes. The project will help alleviate water shortages in the Qadaa Kesrouan and parts of the Metn regions.

Lebanon generates an estimated 310 million m3 of wastewater per year, of which 249 million m3 is produced by the domestic sector with a total BOD load of 99,960 tonnes, and an estimated 61 million m3 by industry. This represents an increase of 88 per cent compared with 1991 when 165 million m3 was generated. In 2006, treated wastewater was only 4 million m3, of which 2 million m3 was destined for agricultural purposes, and the rest disposed of in the marine environment by direct diversion to the rivers, or infiltrated by deep seepage to groundwater. The potential for reuse of domestic wastewater is estimated at around 100 million m3/year. Some illicit irrigation from untreated wastewater is practised. Another source of non-conventional water is desalinated sea water, which is estimated to be 47.3 million m3 [Mdalal, 2006].

1.1.2. WATER USE

It is difficult to determine the exact figure for water withdrawal and to make a realistic breakdown between the different sectors. Most private wells are unlicensed and therefore not monitored. In addition, a large share of water in public distribution systems is lost through system leakages. There is 35–50 per cent seepage from the water supply networks, which is almost all infiltrated to the aquifers and extracted again via tube wells, especially in the Greater Beirut metropolitan area.

In 2005, water withdrawal was estimated at 1,310 million m3, of which almost 60 per cent was for agricultural purposes, 29 per cent for municipal use, and 11 per cent for industry. Primary groundwater and primary surface water account for 53.4 per cent and 30.2 per cent respectively of total water withdrawal. Recycled irrigation drainage accounts for 12.6 per cent, desalinated water for 3.6 per cent and reused treated wastewater for 0.2 per cent. The share of water withdrawal for agriculture is likely to decrease over the coming years as more water will have to be diverted for municipal and industrial purposes. It is estimated that 700 million m3 per year is used for hydropower, with direct restitution to the natural river course. Domestic water use is estimated on the basis of 220-250 litres per person per day during the dry period and 200 litres per person per day during the wet period. Few data are available on the current or expected water needs of the industrial sector. It is estimated that between 60 and 70 per cent of water used by industry comes from groundwater and the remainder is drawn from surface water resources.

Groundwater abstraction is secured by means of wells, which tap the major aquifers. Around 1,000 wells are scattered in the area of Beirut, with depths varying between 50 and 300m and an average individual discharge of 35l/s. Over-pumping from wells in the Beirut area explains salt water intrusion.

1.2. WATER QUALITY, ECOSYSTEMS AND HUMAN HEALTH

Water quality is adversely affected by agricultural, industrial and domestic wastewater. Leaching of pesticides and fertilizers from agriculture pollutes both groundwater and surface water. Industries release a wide range of chemical effluents, especially into surface water and coastal water. Open dumping also affects surface water quality. It is difficult to estimate accurately the pollution loads into water bodies from the different economic sectors. It can happen that disposal of sewage and industry effluents into the rivers is followed by abstraction from the same rivers at a point further downstream for water supply and irrigation, sometimes even irrigation of salad vegetables. A National Emergency Reconstruction Program (NERP) was launched in the early 1990s, which conceived the design and construction of discharge networks of wastewater and the establishment of treatment plants in almost all the Lebanese coastal and inland cities. In 1995, a Damage Assessment Report was prepared to formulate a policy framework for the wastewater sector throughout the country.

Water-related diseases, especially diarrhoea, are one of the leading causes of mortality and morbidity among children less than five years old. In addition, health problems resulting from exposure to water pollutants often result in health care costs and absence from work. Typhoid and hepatitis due to poor water quality result in a larger number of sick persons in North Lebanon, South Lebanon and Nabatiyeh [ACS, 2006]. In addition to health impacts, poor water quality increases the cost of water treatment and encourages people to buy more bottled water than they would normally purchase if they had access to good quality drinking water.

Lebanon and neighbouring areas are witnessing a drastic change in climate characterized by persistent droughts. In addition, water quality degradation has reduced the availability of fresh water quantities for drinking as well as for irrigation [Jaber, 2002].

There are three types of water pollution in Lebanon [Jaber, 2002]:

- Pollution by organic materials;
- Pollution by chemicals; and
- Seawater intrusion to coastal underground water.

Pollution by organic materials mainly comes from wastewater from domestic use, domestic solid wastes, animal farms, slaughterhouses, agricultural fertilizers, hospital waste, and food processing waste. Chemical pollution on the other hand, comes from fuel and gas stations, industrial wastewater, pesticides and fertilizers, and quarries. Seawater intrusion is the intrusion of saltwater due to excessive pumping of groundwater along the coast [Jaber, 2002].

Curative solutions are those that are taken after the pollution has occurred. Preventative solutions on the other hand, are those steps taken to avoid pollution. Past studies indicate that 70 per cent of the water resources in Lebanon were polluted in the early 1990s. In 1997, however, studies showed significant ameliorations in areas where rehabilitation activities had been carried out [Jaber, 2002].

The Ministry of Energy and Water (MEW) has established water quality testing laboratories in most water authorities. It has also established a monitoring unit (within the Ministry) and built various treatment plants for drinking water. It is also worth noting that MEW has commenced operations to artificially recharge some underground aquifers [Jaber, 2002].

2. GOVERNANCE ASPECTS

2.1. WATER INSTITUTIONS

Under Law No. 221/2000, several institutions are in charge of water-related issues [Hamamy, 2007].

Two directorates - the General Directorate of Hydraulic and Electric Resources and the General Directorate of Operation, implement water policy and extend and monitor the implementation of hydraulic and electric projects. It applies laws regarding the protection of public water and its use and it is responsible for the administrative supervision of the water and wastewater establishments. It also controls hydraulic and electric concessions and applies mining laws.

The Ministry of Public Health monitors and controls water quality. The Meteorological Service of Civil Aviation of the Ministry of Public Works collects precipitation data. Municipalities and the Ministry of Interior and Municipalities are responsible for the collection of wastewater.

The GP works under the sponsorship of the Ministry of Agriculture and is responsible for constructing earth ponds and small water reservoirs.

The LRA is the only water authority to retain special responsibilities and functions that extend beyond its administrative region (the natural boundaries of the Litani basin). It is responsible for developing and managing irrigation water and associated works in southern Bekaa and south Lebanon. It is also in charge of measuring surface water along the Lebanese territory. Law No. 221/2000 provides a two-year transitional period for reorganizing the existing water boards into regional water authorities.

2.2. WATER MANAGEMENT

Technical aspects of irrigation management include the implementation of cost-benefit analyses for medium and large irrigation projects and cost-recovery of water delivery over time. Historically, the utilization of large pumps to lift water from deep wells, combined with the cost of pumping water, has led to high costs of irrigation water for farmers. Added to this, the quality of water available to farmers has gradually deteriorated due to heavy use of agricultural inputs. The small size of irrigation schemes, land fragmentation and poor services have left a gap in water management policy in Lebanon. Experience of local water management derives from specific cases of rehabilitation of public schemes using both traditional and pressurized irrigation systems. In private schemes considerable experience was gained in irrigation management because more investment was made in the sector.

Recently, increasing attention has been paid to water management issues and the improvement of water use efficiency, for instance, by using appropriate irrigation methods and water harvesting techniques. Research conducted at the Department of Irrigation and Agro-meteorology of the Lebanese Agricultural Research Institute (LARI) and at the American University of Beirut, Faculty of Agriculture and Food Science focuses on improving water use efficiency both in irrigated and rainfed agriculture [Karam et al, 2003, 2005, 2006]. Field research dealing with supplemental irrigation of cereals and legumes is important because it leads to an increase in yield in scarce water environments. However, the dissemination of results and transfer of knowledge to end-users at farm level is still inadequate.

In some public schemes geared to demand, an engineering approach has been adopted in respect of water management, focusing on improving network performance and distribution uniformity and applying a sustainable water tariff system. However, the non-existence of water-user associations led to poor water management at scheme and farm levels. In contrast, in private irrigation schemes, experience in water management was gained through increasing investment in the sector and the presence of highly qualified workers.

To overcome problems of water scarcity, the government initiated a water management policy in the early 1990s based on:

-rehabilitation of the already existing irrigation schemes;
-reorganization of the water sector;
-launch of the ten-year master plan for water storage in dams and earth ponds; and
-implementation of new irrigation schemes using advanced pressurized distribution systems.

2.3. WATER POLICY AND LEGAL FRAMEWORK

In 2000, the Government of Lebanon approved a reorganization plan for the water sector, including irrigation water, drinking water and wastewater, with the aim of better management, maintenance and effectiveness in the water sector. Law No. 241 (29 May 2000) reorganized the existing 22 water boards into four regional water authorities: North Lebanon for the Governorate of North Lebanon; Beirut and Mount Lebanon for the Governorates of Beirut and Mount Lebanon; South Lebanon for the Governorates of South Lebanon and Nabatiyeh; and Bekaa for the Governorate of Bekaa. Working under the auspices of MEW, the four authorities are in charge of managing irrigation water, drinking water and wastewater. Their responsibilities extend to water policy planning at national level, measurement of water flows in rivers and measurement of groundwater recharge, construction of water storage capacities (dams, reservoirs and earth ponds), monitoring the quality of drinking water and treated wastewater, water pricing, and water legislation. They are also responsible for studying, rehabilitating, implementing and managing water projects in the country (adduction and distribution network).

Law No. 221/2000 empowers the regional water authorities to set and collect water tariffs for domestic and agricultural use. Subscription fees for domestic water supply vary depending on water availability and distribution costs: gravity distribution is cheapest while distribution by pumping is far more expensive. In the Beirut area, where water tariffs are high, water is conveyed long distances and/or pumped from deep wells. In some parts of northern Lebanon, where water tariffs are low, water is available from springs and delivered by gravity. In 2001, tariffs ranged from US$43 to US$153/year for 1m3/day gauge subscription, which is equivalent to US$0.12 to US$0.42 per m3 water per day per household assuming consumption of 1m³ of water per day. However, most households incur additional expenses to meet their water requirements. In fact, most households pay much more on a per cubic metre basis for two main reasons: (i) frequent and periodic water shortages; and (ii) the need to buy water from private haulers, at a cost that is typically around US$5–US$10 per m3. In public irrigation schemes where water is delivered by gravity, water is charged at a flat rate per cropped area. In the irrigation schemes of the Litani, where water is delivered by means of pressurized pipes, volumetric metering is provided. This is the case of the Saida-Jezeen irrigation scheme and in some parts of the South Bekaa irrigation scheme. As an example, water charges vary between US$260/ha in the Qasmieh-Ras-El Ain irrigation scheme in south Lebanon to US$30–150/ha in the Danneyeh and Akkar irrigation schemes in northern Lebanon.

3. GEOPOLITICAL ASPECTS

In August of 1994, the Lebanese and Syrian governments reached a water-sharing agreement concerning the Asi-Orontes River, according to which Lebanon receives 80 million m3/year if the Asi-Orontes River's flow inside Lebanon is 400 million m3 or more during that given year. If this figure falls below 400, Lebanon's share is adjusted downward, relative to the reduction in flow. Wells in the river's catchment area that were already operational before the agreement are allowed to remain in use, but no new wells are permitted. The Asi-Orontes River rises in an area north of the city of Ba'albeck and flows through the Syrian Arab Republic before entering Iskenderun (Alexandretta) and emptying into the Mediterranean Sea. The Al-Azraq spring is a very important Lebanese tributary to the Asi-Orontes River; its annual flow is more than 400 million m3 [Amery, 1998].

In 2002, the water resources of the Hasbani basin became a source of mounting tension between Lebanon and Israel, when Lebanon announced the construction of a new pumping station at the Wazzani springs. The springs feed the Hasbani river, which rises in the south of Lebanon and crosses the Blue Line frontier to feed the River Jordan and subsequently the Sea of Galilee, which is used as Israel's main reservoir. The pumping station was completed in October 2002. Its purpose was to provide drinking water and irrigation for some sixty villages on the Lebanese side of the Blue Line. October 2002 also marked the high point of tension between Israel and Lebanon, with a real risk of armed conflict over the station. The Israelis complained about the lack of prior consultation whereas the Lebanese contended that the project was consistent with the 1955 Johnston Plan for the water resources of the region. The EU and the United States both sent envoys to the region in late 2002 in response to the rising tensions [EU, 2004].

Lebanon and Syria have signed two agreements on their shared rivers. These are the agreements on the Orontes signed in 1994, and the one on the Nahr Al-Kabir Al Janoubi signed in 2002 [Marina, 2010].

The Orontes is a shared river which has its source in Lebanon, flows into Syria, and ends in Turkey. In 1994, Lebanon and Syria signed the Accord Concerning the Distribution of the Orontes. The agreement does not involve Turkey. Negotiations between Syria and Turkey did not lead to any result. An annex was added to the Syrian-Lebanese agreement in 1997, which was ratified only in 2001 by the Syrian-Lebanese Higher Council. Under this agreement, a dam was built in Lebanon on the Orontes with a capacity of 37 million m³ [Marina, 2010].

The Nahr Al-Kabir Al Janoubi forms Lebanon's northern border with the Syrian Arab Republic. The total river watershed area is about 990km², of which 295km² lies in Lebanon [ESCWA, 2006]. Discussions between Lebanon and Syria on sharing the waters of the Al-Kabir Al Janoubi River began as discussions on sharing the waters of the Orontes were progressing. An agreement was reached in 2002. The agreement draws on principles from the UN Convention on the Non-Navigational Uses of International Watercourses (May 21, 1997), which both Lebanon and Syria have ratified.

The main provisions of the Lebanese-Syrian agreement are based on the articles of the UN Convention. The focus of the agreement is the fair and optimal distribution of waters of the Nahr Al-Kabir Al Janoubi and it is based on the principle of realizing mutual benefit for the two sides. The agreement has also established a process of cooperation between the two countries through a joint committee to share information and results. Based on identified needs and requirements for both countries in all sectors (potable, irrigation, and industrial), the construction of a joint dam in the location of Idlin (Syria) – Noura al-Tahta (Lebanon) was decided, with a storage capacity of 70 million m³, according to technical and economic feasibility studies [ESCWA, 2006].

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