UNITED NATIONS

E

Distr.
LIMITED
E/ESCWA/CL1.CCS/2021/WG.14
/Report
15 July 2021
ORIGINAL: ENGLISH

Economic and Social Commission for Western Asia (ESCWA)

Report

Mashreq Waters Knowledge Series: Disruptive Technologies for Improved Groundwater Management in the Mashreq Region

Beirut, 15-17 June 2021

Summary

The World Bank (WB) and the Economic and Social Commission for Western Asia (ESCWA) jointly organized a meeting on Disruptive Technologies for Improved Groundwater Management in the Mashreq Region, which was convened virtually through online platform from 15 to 17 June 2021. The meeting started by highlighting the importance of disruptive technologies for groundwater governance in countries of the Mashreq. In that respect, the Mashreq Groundwater Technologies e-book developed within the framework of the Mashreq Waters Knowledge Series and the various knowledge products were presented as valuable tools to support Mashreq countries in the management of their groundwater resources. The application of novel technologies and artificial intelligence for data acquisition and analysis in region-specific contexts were discussed. The application of available open access online platforms for data management, analysis and visualization leveraging disruptive technologies was demonstrated during the meeting. Following sessions presented examples on how disruptive technologies were used to support innovative approaches to groundwater management in other parts for the world and engaged participants in exchange and discussions on their applicability to the Mashreq region.

Also, country representatives from Islamic Republic of Iran, Iraq, Jordan, Lebanon, the Syrian Arab Republic, and Turkey presented their countries' experience with regards to the use of innovative technologies for groundwater management. Country representatives suggested areas for future Mashreq Waters Knowledge Series focus and further capacity development on the use and application of novel technologies for groundwater assessments, water quality, and analysis adapted to Mashreq region specificities.

CONTENTS

Introduction

1. The meeting on "Disruptive Technologies for Improved Groundwater management in the Mashreq Region" was jointly organized by the World Bank and the Economic and Social Commission for Western Asia (ESCWA), and constitutes the third workshop of a series of training and capacity building activities within the framework of the Mashreq Waters Knowledge series. The first workshop of this series (Beirut, January 2020) discussed how regional collaborative assessments and knowledge platforms can provide a common knowledge base for strengthening water resources management in the Mashreq region. The second workshop (virtual, December 2021) expanded the discussion to consider economic and productivity assessment tools related to the water and agricultural sector under changing climate conditions.

2. This third workshop focused on the use of disruptive technologies to inform and improve groundwater management in the Mashreq region against a backdrop of scarcity and deteriorating quality and impacts of climate change.

3. The meeting consisted of seven sessions. The main meeting deliberations and discussions are presented in this report: Section I of this meeting report highlights the main topics of discussion, while section II reviews the organization of work as well as information regarding the meeting agenda and participants. The meeting documents, including the workshop agenda and delivered presentations, are available at the following website: https://www.unescwa.org/events/mashreq-waters-knowledge-series-disruptive-technologies-improved-groundwater-management.

I. TOPICS OF DISCUSSIONS

4. Presentations and main discussion outcomes are presented in the following sections according to the substantive sessions of the meeting.

A. Overview of Disruptive Technologies for Improved Groundwater Management

5. ESCWA presented an overview of groundwater status globally and in the Mashreq with a focus on institutional governance, challenges, and opportunities. The main challenges facing groundwater governance at the global level are linked to its invisible nature which is worsened by a lack of data and information, and anthropogenic pollution which further limits its availability, and when it is transboundary, cross border coordination for groundwater governance gets even more complex. In the Mashreq region, all countries share one or more of the 24 transboundary aquifers. Lack of good management and monitoring practices have led to uncontrolled well drilling, mostly for agriculture production and leading to groundwater depletion, which is further aggravated by a growing population and impact of climate change. GRACE-derived groundwater storage anomaly data demonstrated considerable declines in groundwater table levels in Jordan, Syria, Iraq, and Islamic Republic of Iran. Unsustainable extraction patterns have had quality implications such as increased groundwater salinity. The groundwater governance framework was presented as relying on accurate and widely shared knowledge and science, appropriate institutional framework, conducive legal framework and supporting policies and incentives. The role of disruptive technologies in supporting the groundwater governance framework was emphasized particularly for the acquisition of reliable data, data analysis and information generation as well as in disseminating key messages to inform planners and decision makers. It was highlighted in the coming year 2022, many global events would be dedicated to groundwater, as such the UN-Water nineth Water Development Report will focus on Making the invisible visible and the 2022 World Water Day (22 March) will be convened under the same theme. Also, a Groundwater Summit will be held from 7 to 8 December 2022 in Paris, France.

6. The World Bank then presented the Mashreq Groundwater Disruptive Technologies E-book. The presentation introduced World Bank Disruptive technology knowledge products that can be drawn upon to improve the entire data chain starting with data collection, management and analysis; leading to facilitating access and outreach to generated data and information. Three types of World Bank knowledge products are being developed within the framework of the Mashreq Waters Knowledge Series Initiative and include the existing Mashreq Water Data Portal (https://spatialagent.org/Mashreq/) which was launched last year and is continuously updated. Another knowledge product, the Mashreq Water knowledge Portal (https://spatialagent.org/Mashreq/filter.html) facilitates access to interactive, filterable articles, reports, videos, websites; and other knowledge resources of relevance. An interactive E-Book was introduced as the newest Disruptive Techonology (DT) product

(https://spatialagent.org/MashreqDTGW) developed by the Disruptive KIDS (Knowledge, Information & Data Services) Helpdesk of the World Bank and features a wide range of interactive elements (e.g., hyperlinks, photo galleries, video galleries, interactive graphs, interactive maps, interactive data/knowledge filters, etc.) drawing upon multiple online resources. The way data acquired through bottom-up and top-down approaches is processed through cloud supported services to generate useful knowledge used to inform various groups of concerned stakeholders was explained. Also, new ways of visualization are coming into effect through touch screens, physical interactive models, touch tables and projectors as well as other interactive virtual visualization. These techniques were showcased and include an example of three-dimensional remote visualization of dam site.

7. Ensuing discussions highlighted challenges facing the management of groundwater resources found in karstic aquifers therefore, requiring more hydro informatics to better understand these particularly challenging types of geological formations. Also, the hydro informatics is generating quasi instantaneous data at increasingly affordable cost makes them a valuable tool to test the efficiency of implemented policies in achieving the pursued groundwater management goals and objectives.

B. Measuring the Unseen, from Field to Space

8. A representative from Innovative Hydrology delivered an intervention on state-of-the-art technology for In-Situ Monitoring. Despite delays in the advent of novel in-situ groundwater monitoring technologies, recent innovations have brought game changing solutions in that field. Historically, groundwater was not adequately accounted for in the hydrologic cycle, which has challenged effective monitoring and assessment of these resources. Traditional groundwater quantity and quality measurements have relied for long on highly laborious manual approaches based on steel and electronic tape solutions. Automation of these processes resulted in the currently two most used solution categories. The first is based on water pressure measurements and include vented or absolute sensors and non-vented pressure measuring devices. The other category covers the sonic water level meters which are battery operated manual devices that are best applied to shallow wells and integrate immediate data capture and built-in data logger. Although these automated approaches feature many advantages over manual in-situ ones, they need to be combined with continuous readings to capture a comprehensive image of what is really happening underground.

9. A representative from University of Virginia presented experience with monitoring Groundwater from Space. The role of satellite sensors in bridging data gaps for groundwater applications was emphasized. Gravity Recovery and Climate Experiment (GRACE) was used to monitor Changes in Terrestrial Water Storage Anomalies (TWSA) in 14 countries over the Mashreq region, in addition to the Tigris-Euphrates and Nile river basins for the period extending from April 2002 to June 2017. Outcomes indicate declines in water storage over the entire Mashreq region at an estimated rate of change at: -3.18 cm/ year (regional mean). The Northeastern Mashreq region (Jordan, Iraq, Syria, and Lebanon) seems to be the most impacted with other regions such as the Gulf countries exhibiting declining TWSA trends as well. Examination of Changes in TWSA (surface and groundwater) over major water basins in MENA has indicated large water storage declines in the Tigris and Euphrates basins as compared to the Nile basin. Furthermore, declining water volumes in the Tigris -Euphrates were associated with increased incidence of meteorologic drought as evidenced by surges in the Standardized Precipitation Evapotranspiration Index[1] (SPEI). The presentation concluded that in the absence of sufficient in-situ groundwater data in the Mashreq region, satellite-related products present unique opportunity for the assessment of groundwater changes at large scale.

10. A representative from Brigham Young University discussed means and approaches to leverage Earth Observations and Machine Learning for Sustainable Groundwater Management. The West Africa Project aimed to assist stakeholders and water managers in West Africa to assess, characterize, and sustainably manage groundwater resources for economic development and drought resilience. This is pursued through the development of a set of geospatial tools, notably GRACE regional Sub-setting and Groundwater Data Mapping tools to support stakeholders in assessing and interpreting groundwater data and which can be accessed with minimal infrastructure or computer expertise (http://hydroinf.groups.et.byu.net/servir-wa/). Extreme Learning Machine (ELM) is used to infer missing in-situ groundwater data from available Earth observations and to

[1] (SPEI) was first proposed by Vicente-Serrano et al. (2010) as an improved drought index that is especially suited for studies of the effect of global warming on drought severity.

perform more accurate interpolation to estimate water levels over periods where measurements are missing at unprecedented processing speeds. Furthermore, knowledge products generated under the project help support water managers gain better insight regarding of the status of groundwater resources and determine how aquifers are responding to groundwater development, droughts, and climate change.

11. Questions were raised regarding whether methodologies presented in Groundwater from space are applicable to contexts of aridity, which is the prevalent climate feature of the Mashreq region. The efficacy of remote sensing for deep groundwater aquifer applications such as those found in many watersheds of the Mashreq region was discussed. It was confirmed that remote sensing technologies can detect deep groundwater aquifers, nevertheless, it was clarified that in the case of layered aquifer systems, changes in water volumes are calculated for the cumulative variation across the entire depth of the overlaying aquifers. Furthermore, mapping of subsurface geology was discussed, and it was clarified that although radars cannot map subsurface geology, these can detect faults and other geological structures which could eventually be drawn upon to inform subsurface geological mapping. Concerns related to uncertainties in GRACE measurements were discussed and it was clarified that NASA generates and reviews global uncertainty maps for GRACE data on a regular basis. Furthermore, it was clarified that NASA filters out gravity profiles to eliminate interferences resulting from seismic activity prior to dissemination to the public. On the accuracy of the presented in-situ water quality measuring devices (Aquatrack), it was clarified that these technologies rely on traditional approaches applied in surface water contexts for the collection of water quality parameters but adapted to fit in boreholes, therefore, they are considered as highly accurate.

12. Main limits to these space DTs are their applicability to small scale contexts, which is a major impediment specially in watersheds where local communities depend for their water requirements on groundwater resources. It was agreed that the best approach to support decision making in the context of watersheds would be by combining complementary data and information generated from all available sources such as satellite imagery, in-situ observation wells and hydrological modelling.

C. COUNTRY PRESENTATIONS

13. During this session, examples were presented on the Challenges and Opportunities regarding the Use of Disruptive Technologies in countries of the Mashreq region.

14. ***Experience in implementing DT in Iraq*.** The Iraqi representative presented a project implemented to assess the most efficient uses of groundwater resources, in identified pilot areas facing the economic and social risks from dwindling groundwater resources on which local communities dependent for their livelihoods. For that purpose, a water allocation optimization model was developed and was run in association with the General Algebraic Modeling System (GAMS) to minimize water table drawdown and optimize the net benefit generated. The Optimization model have been used to help solve groundwater problems over the past decades by setting a set of objectives and identifying the variables under a series of constraints. The application of the optimization GAMS model was used for the first time ever in hydrological analysis applications in Iraq. Different scenarios were analyzed under varying hydrological, agricultural production and economic variables to try and identify optimal levels of water abstraction and subsequent allocation of extracted water among its competing uses. The successful implementation of the model has confirmed the suitability of GAMS as an efficient disruptive technology tool used to inform decision makers on optimal groundwater resources use.

15. Ensuing discussions deliberated on the risks of using renewable energy for pumping water since experience shows that solar powered pumps are usually operated for longer periods than their conventional counterparts. Nevertheless, outcomes of Direct Benefit Transfer of Electricity (DBTE) scheme pilots, such as that implemented in Punjab provide an indication on the potential of such schemes for the rationalization of energy use and consequently in controlling water abstraction. Nevertheless, this experience cannot be extrapolated to predict the water/ energy tradeoff selected by farmers in other parts of the world as these would be influenced by context specific parameters such as the prices of electricity and possible water uses, among others.

16. ***Experience in implementing DT in Islamic Republic of Iran***. A large portion of groundwater resources in the country is currently being exploited at unsustainable rates. Experience with applying innovative technologies for groundwater management include the use of remote sensing to analyze changes in Land Use and Land Cover (LULC) as well as Evapotranspiration (ET). Difficulties in applying remote sensing to groundwater

monitoring in Islamic Republic of Iran were mainly associated with extensive dataset requirements, computationally intensive data processing, and the need for extensive involvement and collaboration among concerned stakeholders. Some of these challenges were addressed by developing electronic platforms and applications to facilitate data gathering and sharing of information and through enhancing stakeholders' engagement in the collection of data across the country.

17. ***Experience in implementing DT in Jordan.*** The representative from Jordan presented the background related to remote application in Jordan. The main motivation for implementing remote sensing in Jordan was to control illegal groundwater well development and was initiated few years back by the Ministry of Water and Irrigation with support from GEF[2]. Conventional approaches to control illegal well drilling was performed through periodic field visits but has shown limited efficiency. In that respect, remote sensing was used to map changes in cultivated areas and to detect crop types from which accurate water volumes used on the farm could be deduced. Recently, information collected through satellite imagery to detect water parameters and evapotranspiration are being accepted by the court of law as supporting evidence for disciplinary actions in case of infringement. It was also clarified that remotely sensed data is being acquired at high resolutions reaching up to 30 meters with support from international organizations.

18. ***Experience in implementing DT in Lebanon.*** The representative from the Ministry of Energy and Water in Lebanon presented an overview of the groundwater situation in Lebanon. The use of groundwater in Lebanon was legislated by a series of issued laws and decrees since 1926. The authorization procedure is based on excavation and investment (use) permits. Nevertheless, groundwater resources are being depleted at an increasing rate as a result of unsustainable practices of illegal well excavation and exploitation. A groundwater assessment study was undertaken in 2014 which depicted the distribution and abstraction rates of public wells across the country. Groundwater resources contribution to the yearly national water budget was discussed and it was highlighted that a considerable portion of these resources is lost through seepage to the sea and through border crossing. Therefore, there is a need to develop a groundwater model to inform the sustainable use and development of these threatened resources.

19. ***Experience in implementing DT in Syria.*** The representative from Syria shared difficulties faced in monitoring and controlling the use of surface and groundwater resources under protracted conflict situations and the ensuing vandalization of equipment and institutions. Furthermore, war conditions have resulted in the loss of historical water monitoring data. Recently, regional and international organizations have been engaged in the rehabilitation of damaged equipment and human capacities needed for water governance.

20. ***Experience in implementing DT in Turkey.*** The representative from Turkey highlighted that groundwater resources are considered a critical water source for the agricultural, industrial, and domestic sectors and presented the main challenges in managing these resources in the context of complex geological and geomorphological environments. Since 1990, the government has been introducing novel technologies for water resources management through the modernization of irrigation systems and by imposing the installation of metering devices at the entire river basin scale. Also, within the context of the EU Water framework Directive, several action plans were developed and implemented towards the achievement of good quantitative and chemical status of groundwater. These cover enhanced use of smart technologies to better monitor both surface and groundwater resources, enhanced integration of automation, cultivation on soil free media with accompanying supporting finance schemes. Despite these advances, challenges facing the use of groundwater resources persist mainly in term of excessive abstraction and pollution.

21. ***Experience from the application of Disruptive technologies by regional Organizations*.** The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) has been applying computer simulation models for groundwater analysis since the late seventies to better understand flow systems and predict impacts of infrastructure developments and climate change on these resources. Remote sensing technologies were also integrated in information systems for water resources management. The applications of these technologies to specific contexts were presented and included groundwater flow and contamination transport modelling in the Bekaa Valley, Lebanon. Also, similar models were developed to better understand and predict sea water intrusion and accordingly propose solutions in coastal aquifers such as the Ras el Jabal basin in Tunisia. ACSAD also presented the outcomes of a Decision Support System (DSS) developed to generate a user friendly and efficient

[2] Global Environment Facility

water planning and management tool in the Middle East and beyond. The DSS consists of two components: the water evaluation and planning software WEAP[3], and the three-dimensional groundwater flow model MODFLOW[4]. The outcomes of the DSS implementation in identified water basins in the areas were presented and resulted in groundwater planning scenarios for the period 2005-2017 under varying climate change, water demand and boundary conditions scenarios. Future applications of the system could be complemented with the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR) climate and hydrologic projections generated for the Arab domain.

22. ***Experience from the application of Disruptive technologies by academic and research institutions*.** The American University of Beirut (AUB), presented the applications of advanced technologies for the conceptualization of groundwater systems in selected pilot sites in Lebanon. The Groundwater Monitoring Project is the culmination of long years of research encompassing data acquisition and analysis, water quality testing, flow modelling and transport characterization. The rationale behind this project was the development of scientific evidence to support groundwater management policy options, especially in the context of groundwater flowing in karst geological formations which are particularly difficult to predict and manage. In situ multi parameter probes were used to collect information on depth to water level, temperature, chloride, pH, and electrical conductivity (EC), turbidity; etc.; and were used in combination with high resolution satellite imagery to detect snow cover data. The methodology to generate useful knowledge from information generated was demonstrated. Variations in turbidity would be drawn upon to inform regarding the risk of contamination, and data on snow cover melt can be used to inform decision making on potential groundwater recharge. A dashboard is currently being finalized under the project follow-up phases to support a better visualization and understanding of data collected and consequently support more efficient decision making.

23. In response to inquiries raised by participants, it was clarified that remote sensing was applied in the Islamic Republic of Iran at the national level to monitor changes in water balance and for research purposes, however, these technologies were not deployed at small scale levels. Also, with regards to coordination among various institutions and stakeholders engaged in the application of novel technologies to water monitoring and assessment, it was clarified that the Supreme Water Council has the leading role in that respect. ACSAD experience with implementing technologies to small scale contexts was discussed and includes satellite imagery to generate knowledge on water productivity at the farm level, Copernicus-based evapotranspiration (ET) products for the generation of just in time information on water levels in lakes, dams, reservoirs, and which could be drawn upon to estimate changes in groundwater levels. It was clarified that despite the endorsement of satellite imagery for data collection on groundwater use by the Ministry of Water and Irrigation in Jordan, this has not been accompanied by any structural change within the concerned ministry to institutionalize the use of such technologies. Regarding the expansion of the use of such technologies by the private sector, it was mentioned that the application of smart technologies for water management and use planning is predominantly implemented by the public sector in Turkey. Nevertheless, recently, community-based initiatives have resorted to the application of these technologies in specific locations such as Konya led by the Union of irrigation cooperative.

D. Data Management, Analysis and Visualization

24. The World Bank presented an interactive session illustrating the way tools and knowledge base accessible through the E-Book can be built upon to support groundwater analysis. The e-book (https://spatialagent.org/MashreqDTGW/) was put in place to leverage rapid advances in disruptive technology for groundwater management. It has been developed as part of the Mashreq Water Initiative by the Disruptive KIDS (Knowledge, Information & Data Services) Helpdesk of the World Bank. The e-book contains text and interactive graphics that enhances the user's knowledge and learning experience, with links to the Interactive Mashreq Knowledge Resources Tool (https://spatialagent.org/Mashreq/filter.html). The three "Is"[5] were emphasized for better groundwater management and which include Information to better understand and monitor groundwater systems, Institutions to coordinate work across spatial and sectoral scales and Investments needed for planning and operational aspects of groundwater management. Also, it was clarified that disruption is affecting all stages of the data chain causing a paradigm shift in data collection, analysis and sharing of

[3] Water Evaluation and Planning System (www.weap21.org)
[4] Modular hydrologic model (MODFLOW) is considered an international standard for simulating and predicting groundwater conditions and groundwater/surface-water interactions (www.usgs.gov)
[5] Information, Institutions and Investments.

information. Traditional approaches of handling data through record keeping, static and episodic data collection are being replaced with digital portals and applications for continuous, real time data services, visualization and analysis-ready cloud data services that are open public domain accessible to all and which support integrative and collaborative approaches. There is still a lot of potential to leverage global, regional and national hydro informatics data and analytics for subsequent use at small scale local contexts. Nevertheless, in order to make the best use of these capacities, open access data service platforms have to be improved, notably through collaboration across borders and sectors and through greater youth engagement.

25. The following presentation showed the results of an ESCWA study conducted to assess climate change impacts on groundwater resources in the Tadla aquifer complex system, Morocco. The methodological approach was explained and covered the development of a hydrogeological geodatabase to facilitate data use and analysis by GIS tools. Furthermore, projections of precipitation, temperature and hydrological parameters generated under RICCAR[6] were integrated into the geodatabase. A three-dimensional conceptual groundwater model was then developed to simulate the impacts of climate change on groundwater based on anthropogenic and climate forcing under two emission scenarios, RCP 4.5 and RCP 8.5. Simulation outcomes show that water availability in the aquifer system would decrease for both scenarios, groundwater table declines are estimated to reach 10 m under RCP 4.5 to more than 25 m under the worst-case scenario. The presentation concluded with a set of recommendations for climate change adaptation in these regions notably by enhancing productivity in the agriculture sector and through a shift to climate resilient and water efficient crops.

26. The following intervention presented the GEOGIoWS ECMWF Streamflow services (https://geoglows.ecmwf.int) as an open source online hydrologic analysis leveraging disruptive technology. These GEOGloWS ECMWF streamflow services are based on a Hydrologic Modeling as a Service (HMaaS) approach which brings about a paradigm shift for the delivery of reliable streamflow forecast information. The services are based on the centralization of cyberinfrastructure, human capacity, and other components of hydrologic modeling building on global expertise and latest ICT advances to deliver reliable forecasts. This revolutionizes the traditional approaches which typically involve sequential steps starting with the development of individual hydrologic models from global data sources, downloading of input data, creation of models and computational capacities to run and calibrate the suggested models. As such, the GEOGloWS global streamflow forecasting service avails water intelligence needed by decision makers to solve water management issues and supports global economy by informing high-risk investment decisions. Main features of the technology were presented particularly the streamflow hydroviewer which supports animated simulations of streamflow networks around the globe with possibility to perform various customizations.

27. The World Bank exposed how disruptive technologies can be applied to all stages of groundwater management by reinforcing the basics for technology and groundwater. Comparison between plots of water depths variations with time collected manually were compared to those collected by a datalogger. The results highlighted the importance of continuous data collection for the generation of accurate information essential for efficient decision making. The importance of developing conceptual models for groundwater flows, complemented with reiterated testing and calibration was emphasized. Also, it was concluded that all available tools and methodological approaches need to be used in combination for accurate aquifer characterization starting with standard field surveys and reaching innovative artificial intelligence (AI) techniques.

28. The following intervention presented a coupled human-natural systems analysis of Water Security under climate and population change in Jordan. The nationwide systems model was developed as a tool to evaluate policies aimed at freshwater vulnerability reduction under climate and socioeconomic changes. The model was run for 5 socio-economic pathway projections for Jordan, under two representative concentration pathways (RCP 4.5 and 8.5). These scenarios were tested under identified policy interventions covering demand management approaches (double the tariff on large consumers and reduce illicit water use), water reallocations (25 percent from agricultural to urban), supply augmentation through desalination and halving the physical water losses. Model outcomes have shown that in the absence of any interventions, most of low-income households will face extreme water insecurity (less than 40 liters of water per capita per day) by end of the century. Other parameters have indicated consistent trends in widening disparity in freshwater uses, extended durations of water shortage and declining economic welfare under business as usual scenarios. The presentation concluded that in order to

[6] RICCAR acronym definition

effectively address water security challenges, the country needs to endorse all possible policy interventions to achieve greatest benefits for all socio-economic groups studied.

29. Participants deliberated on the outcomes of the Jordan coupled Human-Water model and discussed the applicability of the various proposed interventions to the Jordanian context. Also, it was clarified that detailed information regarding the methodological approach and outcomes of the study were published in the paper: Yoon et al., A coupled human–natural system analysis of freshwater security under climate and population change, 2021, Proceedings of the National Academy of Sciences, April 6,2021. 1118 (14) e2020431118; https://www.pnas.org/content/118/14/e2020431118\

E. Innovative Approaches to Groundwater Management

30. The World Bank representative delivered a Keynote address stressing the importance of groundwater as a strategic resource for countries of the Mashreq region. Inadequate management approaches practiced over long periods of time have led to unsustainable use patterns and resulted in depletion of these resources. Furthermore, RICCAR climate and hydrologic projections indicate that climate change impacts would further exacerbate pressure on groundwater in the Mashreq region**.** The World Bank Group's strategy in addressing global challenges such as the global pandemic and climate change impacts is based on a framework integrating Green, Resilient and Inclusive Development (GRID) considerations. Examples for the implementation of the GRID framework in the Mashreq region were presented in the context of groundwater management in Morocco and Jordan. It was highlighted that disruptive technologies have an important role in enabling and operationalizing a GRID framework approach to groundwater management in the Mashreq region.

31. Meeting participants deliberated on the importance of trade in virtual water across boundaries and its role in strengthening regional integration. It was agreed that importing food products would alleviate pressure on national water resources. Nevertheless, in order to achieve sustainable gains, this strategic measure needs to be part of a comprehensive national water resources management framework. Other approaches focusing on the reduction in water losses, notably through the reduction of food losses need to be considered as well. Furthermore, a thorough understanding of the local context in terms of incentives, national priorities and the institutional framework is also a crucial prerequisite, in addition to cross sectoral coordination and cooperation. Incentives for shifting investments away from polluting industries towards green sectors were discussed and cited the decarbonization of emitting sectors, issuance of green bonds and mainstreaming climate considerations in national development planning and budgeting. Human capacity is crucial to bridge science and knowledge into policy measures.

32. Experience in implementing Managed Aquifer Recharge as an Innovative Groundwater Storage was presented as a water harvesting intervention to store excess precipitation received during wet periods (buffer water) in groundwater aquifers under controlled conditions, for subsequent use in drier seasons. The role of remote sensing technologies in implementing sand dams for groundwater recharge in rural and urban contexts in Somalia was presented. In rural areas, remote sensing technologies facilitated the identification of suitable sites for potential dams, supported technical design and helped assess the impact on the surrounding ecosystem. In urban contexts these technologies were used for the construction and maintenance, notably through remote and automated control, as well as for data and information management (dashboards). It was highlighted that disruptive technologies have facilitated the successful implementation of these sand dams and resulted in the expansion of the scope of their application to enhance water availability by farmers in Somalia. Furthermore, it was clarified that the managed aquifer recharge approaches (MAR) presented during this session were implemented in the context of shallow groundwater aquifers. Applying MAR to deep groundwater aquifers such as those characterizing the Arab region would probably be more complex and costly.

33. The World Bank presented an innovative Electricity-Groundwater Management approach in India. The Government of Punjab has been implementing, since 2018, an innovative scheme called "*Paani Bachao Paise Kamao (PBPK)*" to incentivize farmers to use water and electricity more efficiently, while maintaining supply of free power to agriculture on the understanding that they install digital electricity meter on tube well. The scheme builds on Direct Benefit Transfer of Electricity (DBTE) approaches whereby electricity saved by farmers is monetized through direct cash transfers. The benefits generated from the implementation of the project were presented in terms of energy (KWh) saved, money earned by farmers and total carbon emission saved. The main outcomes of the project were emphasized in that it succeeded in overcoming decade long objection of farmers to

metered electricity consumption. Also, the project inspired the government of India to encourage other states to implement similar DBTE schemes. The above scheme was complemented with demonstration farms where water efficient techniques and advanced agronomic practices are piloted. In scaling up these experiences, the way forward for such schemes considered solarization of agricultural production which is much more efficient in achieving benefits in the three sectors, however, implementation of such approaches is hurdled by heavy coordination and governance requirements. Learnings from implementing a DBTE scheme to incentivize farmers for the efficient use of electricity to tackle depleting groundwater, energy efficiency, and the power subsidy burden for agriculture was discussed. The rationale for the project was to reverse the prevailing adverse Energy-water-agriculture Nexus.

34. Experience with implementing well designed solar irrigation options was presented by the International Water Management Institute (IWMI). The SKY pilot project was launched in Gujarat to deploy solar powered irrigation on a net metering basis. The project succeeded in overcoming longstanding resistance to metering by heavily subsidizing energy supply to joining farmers. Furthermore, farmers were allowed to export surplus electricity to the power distribution company. The outcomes of the project have demonstrated net benefits to the farmers, the utility, climate and the environment.

F. GROUNDWATER KNOWLEDGE FRAMEWORKS

35. Capabilities and possibilities of the Mashreq Data Portal were demonstrated through an interactive session organized by World Bank for that purpose. It was emphasized that traditional ways in analyzing data are being disrupted by cloud computing which supports up to thousand times faster processing rates. Data analysis through a cloud-based platform was demonstrated using the Google Earth Engine (GEE) which integrates GIS and remote sensing capabilities at unprecedented processing speeds. Furthermore, 3D animations can help visualize how systems complement each other and would lead to linking up various departments concerned in the collaborative management of water resources. Participants were invited to contribute their relevant work to the e-book which supports many languages including Arabic, Persian and Turkish. It was concluded that information generated through various data acquisition systems can be integrated with cloud supported data management tools and global analytics services to generate useful information needed for different categories of use and application.

36. The representative from the International Groundwater Resources Assessment Centre (IGRAC) presented the Global Groundwater Information System (GGIS) https://ggis.un--igrac.org/igrac.org/ which was launched to address knowledge gaps in groundwater data and information. It is a web-based Geographic Information System, which supports the storage, visualization, analysis and sharing of groundwater data and information through map-based modules. A dedicated portal provides access to maps, documents, well and monitoring data as well as thematic map viewers. These include among others, the Global Groundwater Monitoring Network (GGMN), maps of the transboundary aquifers of the world, a MAR portal, etc. The GGIS is a highly interactive system that can easily be expanded with new thematic and/or regional (project) modules. It was clarified that Registration to the GGIS is open to all and supports access to otherwise restricted data.

37. The World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) was presented by BGR and is a network including representation from UN specialized agencies, research institutions and networks, regional organizations, experts, academia, etc. The network was launched in 2000 to provide data and information regarding the major groundwater resources of the world. An overview of the breadth of knowledge products shared by the network cover groundwater resources and vulnerability maps, analyses, explanatory notes and booklets as well as map web supported map viewers and services as well as downloadable data. These products provide information on the quantity, quality, availability and vulnerability of groundwater resources and support the communication of groundwater related issues to water experts, decision makers and the general public. The WHYMAP online viewer can be accessed through: www.whymap.org/whymap-viewer.

38. A presentation by the British Geological Survey (BGS) highlighted the organization's work on the development of the Africa Groundwater Atlas which includes quantitative maps for transboundary groundwater aquifers across the African continent. The types of quantitative data generated cover aquifer depth, water storage and yield, water recharge and depletion. Furthermore, current work is underway for the preparation of salinity maps. The development of these maps relied upon remote sensing techniques for data acquisition and analysis, compilation of historical maps, material from grey literature (unpublished); data gaps were filled with authentic research. Also, consultations and review of the generated maps were conducted during workshops organized for

that purpose. Furthermore, the British Geological Survey has supported the development of the Africa Groundwater Atlas in collaboration with international partners and experts across Africa. The Atlas is an online resource which facilitates access to high-quality groundwater information in 51 African countries. The importance of transboundary maps for cross-border aquifers was reiterated in that they reveal new patterns that would otherwise be overlooked. Collaboration on the preparation of these maps has also enhanced consensus among concerned stakeholders on shared water management issues. The open access data and knowledge generated was heavily consulted which reveals the usefulness and relevance of this type of information.

39. Closing remarks delivered by the World Bank representative noted the interconnected and encompassing nature of groundwater governance challenges. In that perspective, disruptive technologies can support a better understanding of the nature and extent of these challenges. The representative highlighted the priorities of the World Bank's water agenda in the Mashreq region for the coming period, which are centered on the operationalization of partnerships and networking, enhancing exchange of technical knowledge and encouraging civil society engagement, notably the youth. The remarks concluded with a reiteration of the Bank's willingness to continue collaborating with ESCWA and other partner institutions on the Mashreq Water Knowledge Series.

G. Closing Reflections

40. A panel discussion followed whereby Mashreq region country representatives were invited to provide their insights on operationalizing groundwater technologies in the Mashreq region to improve the management of groundwater resources.

41. Country representatives provided their feedback and input with regards to opportunities for the operationalization of DT and possible themes of upcoming related workshops that would best address specific needs of the Mashreq region. Context specific capacity development and training to support technical assessment of aquifer suitability for groundwater recharge was requested. The need for enhanced technical capacities and skills for the assessment and remediation of groundwater quality and the overall water quality thematic were raised as well. Participants also stressed that future workshops convened within the framework of the Mashreq Waters Knowledge Series shall present case studies and examples which are of direct relevance to countries of the Mashreq region. Also, it was highlighted that training on novel technologies shall be organized more frequently to keep pace with rapidly evolving technologies.

42. The challenges, and opportunities facing groundwater governance in the Mashreq region were summarized. A wrap up of potential innovative approaches in addressing these challenges was presented and following steps discussed. Groundwater resources are consistently being overexploited and depleted across the entire Mashreq region. Livelihood is increasingly relying on this water resource type and hence there is a need to integrate social and economic dimensions in analyzing groundwater depletion risks. Another dimension of crucial importance to the region, is the transboundary nature of groundwater basins crossing one or more borders, hence underscoring the need for cooperation among neighboring countries. Furthermore, insufficient governance systems and inadequate management practices are a prevailing feature across the entire region. Even in countries with existing water rules and regulations, these remain very hard to enforce. Data on the invisible resources is lacking and insufficient and leads to uncertainty and further complicates the assessment, planning, management, and the efficient allocation of these resources. Nevertheless, challenges hold opportunities for improvement. Collaborative work across countries of the Mashreq region supported by disruptive technologies can pave the way for regional networking and partnerships. Innovative approaches presented throughout the meeting sessions were reviewed and their role in bridging the data and knowledge gaps for groundwater assessment and management was highlighted. Managed aquifer recharge and solarization of irrigation systems were found to hold promising potential, nevertheless, these must be coupled with appropriate monitoring and control measures to avoid counterproductive outcomes. It was concluded that innovative technologies need to be deployed within a broader framework of coordinated approaches based on principles of Green, Resilient, and Inclusive Development.

43. The World Bank and ESCWA representatives reiterated their commitment to cooperate with all the countries in every way possible. The organizers have taken note of the priority concerns identified by countries. Suggestions will be considered individually, and organizers will assess how the suggested topics could be considered as part of the future activities of the Mashreq Water Knowledge Series. Finally, it was agreed that the Arab Integrated Water Resources Management Network (AWARENET) would present a possible avenue for the delivery of focused webinars and trainings on specialized topics.

II. ORGANIZATION OF THE SESSION

A. DATE AND VENUE

44. The workshop on Disruptive Technologies for Improved Groundwater Management in the Mashreq Region was held virtually, from 15 to 17 June 2021.

B. OPENING OF THE SESSION

45. The World Bank representative opened the meeting by emphasizing the importance of the Mashreq Waters Knowledge Series in providing a regional cooperation platform supporting Mashreq counties in accessing innovative solutions towards the achievement of water security. The approach is based on three work pillars covering the promotion of the narrative, consolidating partnerships through knowledge sharing and enhancing cooperation at the technical level. The importance of collaborative efforts towards a common understanding of the groundwater issues for the Mashreq region was stressed as a crucial step to develop a common vision on how to address these concerns. The World Bank expressed their willingness to share experience gathered in other parts of the world to advance the deployment of available technologies to support the water sector in the Mashreq region. The importance of securing appropriate financing needed to address water sector demands and the role of private sector engagement in that regards was highlighted. Also, the importance of the Mashreq Waters Knowledge Platform in providing the necessary tools and knowledge products for the generation of scientific evidence supporting transboundary cooperation for shared groundwater management was emphasized.

46. ESCWA representative welcomed participants to the third meeting of the Mashreq Waters Knowledge Series which was launched jointly by ESCWA and the World Bank in 2019. The centrality of groundwater for the achievement of the 2030 Agenda across the Mashreq region was emphasized. In acknowledgement to the importance of groundwater, the United Nations has dedicated next year's World Water Day on groundwater theme "*Making the Invisible Visible*" and will hold a global summit dedicated to groundwater in December 2022. ESCWA is supporting these efforts by contributing a regional perspective to the 2022 World Water Development Report, and to the 2022 World Water Day and the Groundwater Summit preparations. Furthermore, groundwater represents a particularly valuable water resource to countries of the Mashreq region which are increasingly relying on this resource type for most of their freshwater needs, under conditions of increased depletion and degradation. ESCWA is supporting Mashreq countries in addressing their groundwater challenges through a myriad of knowledge generation and capacity development activities. Notably, the recently generated RICCAR climate modelling ensemble for the Mashreq Region will contribute to further understanding of climate change impacts on groundwater. Country representatives were encouraged to make use of these projections to inform national planning and policy dialogues by drawing upon these available regional knowledge products and services through ESCWA's Centre for Climate Change Policies.

47. Following a tour de table, the World Bank presented the objectives of the workshop which aimed to examine how disruptive technologies may be utilized to inform and improve the management of groundwater in the region in the face of a multitude of challenges including over abstraction, quality deterioration and climate change.

C. PARTICIPANTS

48. Participants gathered senior officials and technical experts from government institutions responsible for water resources management in the Mashreq region from Iraq, the Islamic Republic of Iran, Jordan, Lebanon, the Syrian Arab Republic and Turkey. Experts from the World Bank, United Nations organizations and international organizations provided support the meeting in addition to the contribution of resource persons from expert institutions. The list of participants is provided in Annex I.

ANNEX I

List of Participants

UN MEMBER STATES

IRAN

Ms. Sedigheh Torabi Palatkaleh
Director General of Macro-Planning of Water and Wastewater Office
Deputy of Water and Wastewater
Ministry of Energy
Water Program Office
Tehran, Islamic Republic of Iran
Tel: +982181606320
Mob.: +98219122042908
Email: storabi@moe.gov.ir

IRAQ

Mr. Ali Abdelrahim Obeed
Chief Geologist, Hydrogeologist
General Commission for Groundwater
Ministry of Water Resources
Baghdad, Iraq
Mob: +964 7735305019
Email: ali.obeed67@gmail.com

Mr. Ammar Ismail Kaittan
Senior Chief Programmer
General Commission for Maintaining Irrigation and Drainage Projects
Department of Information Technology
Ministry of Water Resources
Baghdad, Iraq
Mob: +964 7707772719
Email: amaaraldolaymi@gmail.com

Mr. Laith Abdelsattar Jabbar
Vice of General Director
National center of Water resources management
Ministry of Water and Irrigation
Baghdad, Iraq
Tel: +964 17720240
Mob.: +9647703422949
Email: laith_sattar67@yahoo.com

Dr. Ameer J. Kadhim
Chief Geologists
General Commission for Groundwater
Ministry of Water Resources
Mob.: +9647762845230
Email: ajk77_2006@yahoo.com

Mr. Mohamad Dhari Jassim
Councellor
Office of the Minister
Ministry of Water Resources
Baghdad, Iraq
Mob: +964 7901939352
Email: constadvisor@yahoo.com

JORDAN

Ms. Muna Hussain Ahmed Dahabiyeh
Geologist head department
Mathematical modeling technical affairs
Ministry of Water and Irrigation
Amman, Jordan
Mob: +962 0795553449
Email: mona_dahabiyeh@mwi.gov.jo

Ms. Rihab Al Tarawneh
Director of Investment Plan Directorate
Strategic Planning
Ministry of Water and Irrigation
Amman, Jordan
Mob: +962 0795238741
Email: rehab_aref@yahoo.com

Mr. Waleed Yosef Mousa Nahnosh
Associate Engineer
Aquarium Affairs, Directorate of Licensing of Private Wells
Ministry of Water and Irrigation
Amman, Jordan
Mob: +962 791483999
Email: waleedyosefnahnosh83@gmail.com

Mr. Ali Abdullah Marouf Ghanim
Director
Drought Management Governance Unit Ministry of Water and Irrigation
Amman, Jordan
Mob: +962 799007879
Email: ali_ghanim@mwi.gov.jo

LEBANON

Ms. Nisrine Mohamad Ghattas
Dams and Lakes Engineer
General Directorate of Water & Electricity
Ministry of Energy and Water
Beirut, Lebanon
Phone: +961-1565096
Mob.: +961-3602150
Email: Nisrine.ghattas@gmail.com

SYRIAN ARAB REPUBLIC

Ms. Yasmin Malla
Engineer in the Directorate of International Water and Dams
Ministry of Water Resources
Damascus, Syria
Tel: +963 11 2253794
Mob: +963 935072992
Fax: +963 11 2263203
Email: yasmin52malla@gmail.com

Ms. Sawsan Al Mouhanna
Assistant Director of IWRM
General Commission for Water Resources
Ministry of Water Resources
Damascus, Syria
Tel: +963 11 4410941
Mob: +963 988043767
Fax: +963114431742
Email: almouhanna@yahoo.com

Mr. Abdallah Al Kattea
Director of Integrated Water Resources Manager
General Commission for Water Resources
Ministry of Water Resources
Damascus, Syria
Tel: +963 11 4410941
Mob: +963 930004461
Fax: +963114431742
Email: al_kattea@yahoo.co.uk

Ms. Rana Alakel
Engineer in the Directorate of International Water and Dams
Ministry of Water Resources
Damascus, Syria
Tel: +963 11 2253794
Mob: +963 945509923
Fax: +963 11 2263203
Email: ranaalakel55099@gmail.com

Ms. May Abdullah
Head of Agreements and International law Department
Directorate of International Water and Dams
Ministry of Water Resources
Damascus, Syria
Tel: +963 11 2253794
Mob: +963 994918405
Fax: +963 11 2263203
Email: Abdullahmay.sy@gmail.com

TURKEY

Mr. Mehmet Halit Saraldi
Division Manager
Department of Geotechnical Services and Groundwater/Groundwater Planning
Ministry of Agriculture/General Directorate of State Hydraulic Works
Ankara, Turkey
Tel: +90 312 454 4360
Mob: +90 533 737 9298
Email: mhsaraldi@dsi.gov.tr

Mr. Mehmet AKKOYUN
Engineer
Water Law and Policy Department
Ministry of Agriculture/General Directorate of General Directorate of Water Management
Ankara, Turkey
Tel: +90 312 207 63 34
Mob: +90 553 607 34 12
Email: mehmet.akkoyun@tarimorman.gov.tr

Ms. Yasemin GÖKYEL
Biologist
Investigating, Planning and Allocations Department, DSI
Ministry of Agriculture and Forestry
Ankara, Turkey
Tel: +90 0312 454 5296
Email: yasemin@dsi.gov.tr

Ms. Tuğba Evrim MADEN
Policy Development Coordinator
Policy Development Coordination Office
Turkish Water Institute (SUEN)
Istanbul, Turkey
Tel: +902163254992
Mob: +905324781431
Email: tugba.maden@suen.gov.tr

EXPERTS

Mr. Mark Heggli
Expert
Hydromet
Innovative Hydrology
Email:mark.heggli@innovativehydrology.com

Mr. Venkataraman Lakshmi
Professor
Engineering Systems and Environment
University of Virginia
Email: vlakshmi@virginia.edu

Mr. Norm Jones
Professor and Chair
Civil and Environmental Engineering
Brigham Young University
Email: njones@byu.edu

Mr. Wim Bastiaanssen
Professor
Civil Engineering and Geosciences
Delft University of Technology
Email: wim.bastiaanssen@gmail.com

Mr. Jim Nelson
Professor
Civil and Environmental Engineering
Brigham Young University
Email: jimn@byu.edu

Mr. Michael Souffront
Software Engineer
AquaVeo
Email: msouffront@aquaveo.com

Mr. Steven Gorelick
Professor
Department of Earth System Science
Stanford University
California, USA
Email: gorelick@stanford.edu

Mr. Abdelkader Larabi
Director of Regional Water Centre of Maghreb,
Mohammed V University in Rabat
Rabat, Morocco
Email: larabi_abdelkader@yahoo.fr

Mr. Albert Tuinhof
Groundwater Expert
Email: alberttuinhof@gmail.com

Mr. Mohinder Gulati
Groundwater expert
The World Bank (Retd.)
Email: mgulati@worldbank.org

Mr. Tushar Shah
Researcher Fellow
International Water Management Institute (IWMI)
Email: t.shah@cgiar.org

Ms Joanna J. Doummar
Assistant Professor of Groundwater hydrology
Geology
American University of Beirut
Mob.: +9613936742
Email: jd31@aub.edu.lb

REGIONAL ORGANIZATION

ARAB CENTER FOR THE STUDIES OF ARID ZONES AND DRYLANDS (ACSAD)

Mr. Ihab Jnad
Head of Water Resources Department
Water Resources Department
ACSAD
Mob: +963933593582
Email: ihjnad65@gmail.com

Mr. Mazen Naaman
Water expert
Water resources department
ACSAD
Tel: +963113944410
Mob.: +963966725263
Email: naaman_2@hotmail.com

Mr. Rafiqe Jaber
Groundwater Modeling Expert
Water Resources Department
ACSAD
Mob.: +963 966480077
Email: rafiqejaber@hotmail.com

Mr. Kassem Natouf
Hydrogeologist
Water Studies
Resources Department
ACSAD
Mob.: +963-934556956
Email: qkn212@yahoo.com

Mahmoud Al-Sibai
Consultant
ACSAD
Mob.: +963 933527274
Email: mahmoud.alsibai@hotmail.com

INTERNATIONAL AND UNITED NATIONS ORGANIZATIONS

BRITISH GEOLOGICAL SURVEY (BGS)

Mr. Alan MacDonald
Principal Hydrogeologist
Africa Groundwater Atlas & Transboundary
South Asia Groundwater
BGS
Email: amm@bgs.ac.uk

FEDERAL INSTITUTE FOR GEOSCIENCES AND NATURAL RESOURCES (BGR)

Mr. Stefan Broda
Head of Unit
Spatial Information on Groundwater
BGR
Email: stefan.broda@bgr.de

INTERNATIONAL GROUND WATER RESOURCES ASSESSMENT CENTRE (IGRAC)

Mr. Arnaud Sterckx
Researcher
IGRAC
Email: arnaud.sterckx@un-igrac.org

THE WORLD BANK

Ms. Jennifer Sara
Global Director
Water Global Practice
The World Bank
Washington, D.C., USA
Email: jsara@worldbank.org

Mr. Saroj Kumar Jha
Regional Director, Iran, Iraq, Jordan, Lebanon and Syria
The World Bank
Beirut, Lebanon
Email: sjha1@worldbank.org

Ms. Carmen Nonay
Practice Manager
Water MENA Region
The World Bank
Washington, D.C., USA
Email: cnonay@worldbank.org

Ms. Ayat Soliman
MENA Regional Director for Sustainable Development
The World Bank
Email: asoliman@worldbank.org

Ms. Amal Talbi
Lead Water Resources Management, Middle East and North Africa (MNA) Unit
Water Global Practice
The World Bank
Beirut, Lebanon
Tel: +961 1 987 800
Email: atalbi@worldbank.org

Mr. Anders Jägerskog
Senior Water Resources Management Specialist
Water MENA Region
The World Bank
Washington, D.C., USA
Email: ajagerskog@worldbank.org

Mr. Nagaraja Rao Harshadeep
Global Lead (Disruptive Technology), Environment, Natural Resources and Blue Economy Global Practice
The World Bank
Email: harsh@worldbank.org

Ms. Esha Zaveri
Water Economist
Global Solutions Water
The World Bank
Washington, D.C., USA
Email: ezaveri@worldbank.org

Ms. Lucy Lytton
Senior Water Resources Management Specialist
The World Bank
Washington, D.C., USA
Email : llytton@worldbank.org

Mr. Francois Bertone
Senior Water Resources Management Specialist
The World Bank
Email: fbertone@worldbank.org

Ms. Elvira Broeks
Water and Sanitation Specialist,
Water, Middle East and North Africa,
The World Bank
Email: ebroeksmotta@worldbank.org

Mr. Edoardo Borgomeo
Water Resources Management Specialist
Global Solutions Water
The World Bank
Washington, D.C., USA
Email: eborgomeo@worldbank.org

UNITED NATIONS ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA (ESCWA)

ESCWA
United Nations House
Riad Al-Solh Square
P.O. Box 1107-2812
Beirut, Lebanon
Tel: +961 1 981 301
Fax: +961 1 981 510

Ms. Roula Majdalani
Cluster Leader
Climate Change and Natural Resources
Sustainability Cluster (CCNRSC)
Director, Arab Centre for Climate Change Polices
ESCWA
Email: majdalani@un.org

Ms. Carol Chouchani Cherfane
Chief
Water Resources Section
CCNRSC
ESCWA
Tel: +961 1 978 518
Mob: +961 3 368 248
Email: chouchanicherfane@un.org

Mr. Ziad Khayat
Economic Affairs Officer
Project Coordinator
IWRM for Improved Water Security
CCNRSC
ESCWA
Tel: +961 1 978 517
Mob: +961 3 387 771
Email: khayat@un.org

Ms. Zoubeida Ziadeh
Senior Administrative Assistant
Water Resources Section
CCNRSC
ESCWA
Tel: +961 1 978 855
Mob. : +961 70172282
Email: ziadeh@un.org

Ms. Dima Kharbotli
Coordinator
Arab Integrated Water Resources Management Network (AWARENET)/Research Assistant
Water Resources Section
CCNRSC
ESCWA
Tel: +961 1 978 575
Email: kharbotli@un.org

Ms. Tracy Zaarour
Research Assistant
CCNRSC, ESCWA
Tel: +961 1 978571
Email: tracy.zaarour@un.org