UNITED NATIONS E

ECONOMIC AND SOCIAL COUNCIL

Distr.
LIMITED
E/ESCWA/C.4/2023/4
15 May 2023
ORIGINAL: ENGLISH

Economic and Social Commission for Western Asia (ESCWA)

Committee on Water Resources
Fifteenth session
Beirut, 19–20 June 2023

Item 5 of the provisional agenda

Improved groundwater management through innovative knowledge tools

Summary

The use of innovative knowledge tools can support more efficient and effective groundwater management practices, ensuring the long-term sustainability of this critical resource. Key innovative technologies for groundwater management include in-situ measurement technologies, remote sensing and geographic information systems, groundwater modelling, artificial intelligence, and machine learning. Data accessibility, availability and sharing are the most prominent challenges that the water sector is facing in the Arab region. The use of such technologies is a significant contributor to surpassing these data challenges with the collaborative efforts of various stakeholders. International and regional initiatives on innovative technologies for groundwater management include online platforms that enable quick access and easy processing of large amounts of data without significant technical barriers, which ultimately leads to better decision-making in the water sector.

The Economic and Social Commission for Western Asia (ESCWA) is implementing projects that seek to improve water security in Arab States, with special focus on enhancing the capacity of member States in sustainable groundwater management using innovative technologies. ESCWA and its partners have also studied the impacts of climate change on groundwater resources in Iraq and the State of Palestine. The Committee on Water Resources is invited to review that work, which is summarized in the present document, and advise on the way forward.

Contents

Introduction

1. Effective groundwater management is crucial for ensuring the sustainability of water resources. Innovative knowledge tools play a significant role in improving groundwater management by facilitating the collection, analysis and dissemination of data, information and knowledge. Leveraging innovative technologies, such as remote sensing, modelling techniques, artificial intelligence and machine learning applications, results in a deeper understanding of groundwater systems and in informed decisions on their use and management. Ultimately, the use of innovative knowledge management tools and applications can lead to more efficient and effective groundwater management practices, ensuring the long-term sustainability of this critical resource.

2. The Economic and Social Commission for Western Asia (ESCWA) is implementing projects that seek to improve water security in Arab countries, with special focus on enhancing the capacity of member States in sustainable groundwater management using innovative technologies. ESCWA and its partners have also studied the impacts of climate change on groundwater resources in Iraq and the State of Palestine. The Committee on Water Resources is invited to review that work, which is summarized in the present document, and advise on the way forward.

I. Technologies for improved groundwater management

3. The use of innovative technologies in groundwater management can be a powerful tool to promote the sustainable use and management of this vital resource. Some of the key innovative technologies that can be used in groundwater management include the following:

(a) In-situ measurement technologies can be implemented through a monitoring system that utilizes automatic measurements in a network of wells or springs. In this system, a measuring device is installed in each monitoring well or spring, generating a spatially distributed dataset of various point measurements across a designated study area. This approach provides real-time information on physico-chemical parameters, such as temperature, acidity (pH), dissolved oxygen or contaminants, allowing for a comprehensive understanding of the spatial variability of conditions. Such systems are valuable tools for groundwater monitoring and management, enabling informed decision-making for groundwater conservation and protection;

(b) Remote sensing technologies, such as satellite imagery and geographic information systems (GIS) applications, can provide valuable information on groundwater resources, including data on groundwater quality, availability and use. These data, tools and applications enable better groundwater-management decisions by assisting decision makers in understanding the dynamics of aquifers. For instance, data from the Gravity Recovery and Climate Experiment (GRACE) mission satellite has made it possible to monitor groundwater for the first time, and to assess groundwater storage change at the global and regional levels;

(c) Groundwater modelling is the process of creating a numerical representation of the subsurface water flow in an aquifer system. The model accounts for various factors that affect groundwater flow, such as recharge, discharge and the physical properties of the aquifer. Groundwater models created using the MODFLOW software package can be used to evaluate the impact of various scenarios, such as climate change, pumping rates, and land use change on groundwater resources. The results of these models can help decision makers develop effective strategies for the sustainable management of groundwater resources;

(d) Artificial intelligence and machine learning can be used to analyse and process large amounts of data and provide insight into groundwater management, thus enabling stakeholders to make better assessments and predictions related to groundwater management. In the past two decades, tremendous progress has been made in groundwater level prediction utilizing machine learning models. This processed data is available to the public through online knowledge platforms.

4. The use of different types of innovative technologies is discussed in more detail in chapter 4 of the ESCWA Water Development Report 9: Groundwater in the Arab Region, entitled “Innovations for improved groundwater management”.

II. Challenges and opportunities

5. A major challenge in the management of groundwater resources in the Arab region is the availability, accessibility and sharing of data. However, innovative technologies offer opportunities for addressing these challenges, and promoting sustainable groundwater management across the region. In-situ measurement technologies, remote sensing and GIS tools are examples of innovative technologies that overcome data accessibility and availability challenges by monitoring groundwater resources in real time, and in areas that are physically remote or inaccessible. Data can also be evaluated using artificial intelligence and machine learning to identify patterns and trends, and disseminated through online knowledge platforms that resolve the issue of data sharing. Groundwater modelling, which enables the simulation of various scenarios, makes use of collected data for the simulation and prediction of various scenarios.

6. Overall, the adoption of innovative knowledge tools presents significant opportunities for improved sustainable groundwater management in the Arab region. However, implementation and proliferation of these technologies requires an enabling environment in terms of regulations and institutions, and collaboration between various stakeholders including government and non-government agencies, academia and the private sector.

III. Initiatives using technologies for improved groundwater management

A. Global groundwater knowledge platforms

7. Numerous international organizations use online platforms to share data with water professionals worldwide. These platforms enable free and easy access to data, often allowing direct access, browsing, basic manipulation and download of data, without requiring extensive computing skills or specialized tools. By linking these cloud services with open data standards, the accessibility and usability of data analysis are significantly increased in online contexts. This means that water professionals and managers can quickly access and work with large amounts of data without significant technical barriers, which ultimately leads to better decision-making in the water sector. Examples of these platforms include the following:

(a) The Global Groundwater Information System (GGIS) is a web-based platform that provides users with access to global groundwater-related data and information. This platform allows users to visualize and analyse data related to transboundary aquifers, groundwater levels, quality and stress. This platform is managed by the International Groundwater Resources Assessment Centre (IGRAC);

(b) The World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP), developed by the Federal Institute for Geosciences and Natural Resources (BGR) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), is a programme that offers information and geospatial data on significant groundwater resources globally. The Groundwater Resources Map shows different types of groundwater environments and their geographical coverage, and categorizes them based on their aquifer productivity and recharge potential. The dataset also includes other groundwater-associated features, such as saline areas and wetlands;

(c) The Aqueduct Platform is an online tool developed by the World Resources Institute that provides information on water risk and scarcity worldwide. The platform uses data and mapping tools to help companies, investors and policymakers better understand and manage water risk, and make informed decisions on water resource management. The platform's flagship product is the Aqueduct Water Risk Atlas, which

provides a comprehensive assessment of water risk in 189 countries, based on indicators such as water stress, drought severity, and groundwater depletion;

(d) The African Groundwater Atlas is an online platform developed by the British Geological Survey that provides information on the geology and hydrogeology of the African continent. The Atlas includes maps, datasets and case studies that provide insight into the location, extent and characteristics of aquifers and groundwater resources in Africa. The platform also provides information on the hydrogeological setting of different regions, groundwater management, and the potential for further groundwater development.

B. Innovative technologies for groundwater management: case studies in the Arab region

8. ESCWA, in partnership with Palestinian Water Authority, conducted a technical case study on the Eocene Aquifer in the West Bank to evaluate the potential impact of climate change on the availability of groundwater resources. The study utilized a 10 km^2 grid resolution from the Mashreq Domain of the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR), which simulated climate change impacts up to the year 2060. Climate change impacts on crop yield were also assessed for two crops, maize and potato, in two locations within the Eocene boundary. Six precipitation scenarios generated by the RICCAR Mashreq Domain data were analysed, and their effects on the aquifer's water balance and water level distribution were modelled using MODFLOW. A three-dimensional model was developed, with one layer representing the Eocene formation and other geological units.

9. The study's findings indicate that precipitation and recharge will be significantly affected between 2041 and 2060. Average precipitation decreased in all scenarios between 3 and 12 per cent, whereas recharge exhibited a reduction of 12 to 16 per cent in five out of six precipitation scenarios. Consequently, with no reduction in pumping, water levels in all scenarios decreased. The growth cycle of maize crops in Jenin is expected to decrease by 11 per cent in the short term, and by 18 per cent in the medium term. During this period, there is also a projected decrease in maize yields of 3.3 per cent in the short term, and of 10 per cent in the midterm. In the case of potato crops in Nablus, yields are predicted to be more resilient than maize, remaining unchanged in the short term and declining by 4.5 per cent in the midterm. Water productivity is expected to remain stable for potato crops.

10. ESCWA, in collaboration with the Ministry of Water Resources in Iraq and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), assessed the potential impact of climate change on the Dibdibba aquifer in Iraq using the 10 km^2 grid resolution from the RICCAR Mashreq Domain projections. The study also analysed the impact of climate change on tomato yields. The Ministry of Water Resources in Iraq selected the Dibdibba aquifer owing to its susceptibility to precipitation variations resulting from climate change. Moreover, the increasing demand for groundwater in this region, which is a significant agricultural area and tourist destination, further underscores the importance of the study. Using regional climate projections for the Mashreq Domain, the study demonstrated that climate change would have a significant impact on groundwater resources in the Dibdibba aquifer, leading to a reduction in groundwater storage and a considerable decline in the groundwater table. These findings require that farmers and decision makers take immediate action to mitigate the potential impact of changes in aquifer storage and water level distribution.

IV. Ongoing and future work

Improved water security in Arab States

11. The ESCWA regular programme of work on water security and groundwater is complemented by resources from the following two sources. The United Nations Development Account project on Improved Water Security in Arab States aims to enhance water security by strengthening the capacity of ESCWA member States in the sustainable management of groundwater resources, including the use of innovative

technologies and the assessment of projected impacts of climate change on groundwater resources. The project's objective is to improve knowledge of innovative technologies for groundwater management and of the impacts of climate change on groundwater, through demand-driven pilot case studies in member States and the development of a regional knowledge platform. In addition, the Government of Sweden is supporting work on shared knowledge for improved transboundary groundwater cooperation, which focuses on capacity-building and regional knowledge sharing through extrabudgetary project resources for climate resilience through regional cooperation for inclusive sustainable development. These projects build on regional experience and knowledge products on groundwater, climate change and integrated water resources management to improve water security and advance progress towards the targets of Sustainable Development Goal 6.

1. *Arab Network of Groundwater Focal Points*

12. With the aim of establishing an Arab Network of Groundwater Focal Points, ESCWA has invited countries to nominate a focal point with extensive experience in the field of groundwater. In response, focal points were nominated from various ministries, and their contact information was collected and stored in a database to streamline communication among network members.

13. An inception meeting was convened to introduce the planned development of the Arab Groundwater Knowledge Platform to the network focal points. The meeting introduced planned activities and encouraged focal points to provide their feedback and support by contributing their national groundwater data to populate the platform. The meeting also served as an opportunity to invite countries to express their interest in implementing national case studies on the use of innovative technologies for groundwater management and the modelling of climate change impacts on groundwater.

14. A follow-up regional workshop will be organized to discuss the Arab Groundwater Knowledge Platform; water modelling tools for assessing impacts of climate change on groundwater; and the use of selected innovative technologies for managing groundwater resources.

2. *Arab Groundwater Knowledge Platform*

15. At its fourteenth session, the Committee on Water Resources adopted a recommendation requesting that ESCWA develop a digital groundwater knowledge platform to help decision makers and stakeholders access the latest studies, reports and tools in the field. In response, ESCWA is developing the Arab Groundwater Knowledge Platform that centralizes data on groundwater resources in the region. The platform will serve water and natural resource managers, terrestrial ecosystem experts, climate change studies, and remote sensing data users. It will facilitate access to data and information and thus reduce the time and effort spent by policy advisors, researchers and experts on data collection, preparation and pre-processing. The platform is available and accessible online, and can assist policy advisors and ministries responsible for groundwater management in the Arab region during stakeholder consultations and transboundary dialogues to inform efforts to improve water security in Arab States.

16. The platform brings together all the available remote sensing, geospatial and climate data related to groundwater resources in the Arab region from various sources in a centralized, user-friendly, and highly interactive platform system. The Arab Groundwater Knowledge Platform includes or will include the following:

(a) A comprehensive groundwater database, which includes the Inventory of Shared Water Resources in Western Asia, WHYMAP datasets, African Atlas hydrogeological layers, and related datasets from the International Groundwater Resources Assessment Centre's (IGRAC) Global Groundwater Information System (GGIS);

(b) Integration of multidimensional remote sensing data: Precipitation, Gravity Recovery and Climate Experiment (GRACE) groundwater data, MODIS Vegetation Index Products, land cover types, and additional information related to climate prediction datasets, such as expected seasonal and annual changes in precipitation and temperature from the outputs of RICCAR;

(c) National datasets that will be shared by national focal points to populate the platform with in-situ data;

(d) The updated hydrogeological map was developed in collaboration with ACSAD, and is descripted as the "hydrogeological map update" for the Arab region.

3. *Groundwater modelling for assessing impacts of climate change on groundwater*

17. At least two case studies on the assessment of climate change impacts on groundwater resources in pilot ESCWA member States will be conducted using RICCAR datasets in collaboration with national teams, and a training manual will be developed to conduct national technical workshops for selected countries using the MODFLOW software. Given that the selection of case studies is demand-driven, ESCWA sent a request to focal points to express their interest in conducting the assessment of climate change impacts on groundwater.

18. Three countries have so far expressed their interest in applying the assessment, namely Jordan, the Sudan and Tunisia.

4. *Use of selected innovative technologies for groundwater management*

19. Three case studies on the use of innovative techniques/groundwater analysis tools for groundwater resource management will be conducted. The studies will be carried out in collaboration with national teams, including developing a training manual and holding national technical workshops for the selected countries. Countries are given the following two options to choose from: monitoring groundwater storage changes and recharge with the GRACE satellite mission, or estimating groundwater used for irrigation using remote sensing data.

20. Five countries have so far expressed their interest in participating. Among them, Jordan, the State of Palestine and the Sudan are interested in monitoring groundwater storage changes and recharge using GRACE technology. Moreover, Libya and Tunisia are interested in estimating groundwater used for irrigation using remote sensing data.

21. The GRACE satellite mission aims to monitor and evaluate changes in groundwater storage and recharge in a specific region, utilizing collected data. This includes the following:

(a) Estimating groundwater storage changes in both liquid water equivalent and volumetric storage;

(b) Using the water-table fluctuation (WTF) method on the GRACE-derived storage change data to estimate recharge in the region;

(c) Comparing recharge and groundwater storage trends to precipitation trends in the region;

(d) Developing a training manual and conducting a capacity-building workshop to train national teams to use the technology;

(e) Estimating groundwater used for irrigation using remote sensing data to estimate the amount of groundwater used for irrigation, based on evaporation from crops (daily, weekly, monthly and yearly) using remote sensing data from satellite data.

5. *Hydrogeological map update for the Arab region*

22. ESCWA is collaborating with ACSAD to enhance the Arab Groundwater Knowledge Platform. This collaboration will support the development of the platform by leveraging ACSAD prior work, which includes an updated hydrogeological map of the Arab region.

23. The updated map will build upon existing hydrogeological data from literature and from national focal points at the regional and national levels. The map will improve understanding of groundwater resources by providing a detailed overview of their availability at the national, regional and local levels. This includes presenting a comprehensive depiction of the hydrogeological situation, encompassing both the horizontal and vertical extent of aquifers. Furthermore, describing the physical and hydraulic characteristics of groundwater, such as productivity, storage capacity, depth and water quality, is vital to gaining a complete understanding of this critical resource. A report will be issued with the map to describe the hydrogeological data and related information.

V. Recommendations

24. The Committee on Water Resources is invited to advise on further areas of work that it would like the ESCWA secretariat to pursue on groundwater management. In this regard, the following recommendations are submitted for consideration by the Committee:

(a) Propose measures to strengthen the capacity of the Arab Network of Groundwater Focal Points to assist in their use of innovative knowledge tools, and in the population and updating of the Arab Groundwater Knowledge Platform;

(b) Suggest processes to facilitate access to and the use of innovative knowledge tools available on the Arab Groundwater Knowledge Platform to inform programming, planning and policy development on groundwater resource management at the aquifer level and in discussions with relevant stakeholders at the national and transboundary levels.

25. The Committee may also wish to discuss how the ESCWA secretariat can support members States by undertaking the following:

(a) Continue providing training and technical assistance on the use of innovative tools for improved groundwater management, including under changing climate conditions;

(b) Support the preparation of demand-driven assessment and analysis to inform improved groundwater resource management at the aquifer, national and transboundary levels;

(c) Increase awareness of groundwater management challenges affecting water security in the Arab region, including through regional and international forums in support of internationally agreed water-related goals and targets.
