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International Groundwater Resources Assessment Centre

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2018

United Nations
Educational, Scientific and
Cultural Organization

International
Hydrological
Programme

IGRAC
Report 2018

Delft, January 2019

IGRAC (International Groundwater Resources Assessment Centre) facilitates and promotes international sharing of information and knowledge required for sustainable groundwater resources development and management worldwide. Since 2003, IGRAC provides independent content and process support, focusing particularly on transboundary aquifer assessment and groundwater monitoring.

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CONTENTS

LIST OF ACRONYMS

ANBO	African Network of Basin Organizations
AMCOW	African Ministers' Council on Water
AWRA	American Water Resources Association
BGR	Institute for Geosciences and Natural Resources
BGS	British Geological Survey
CeReGAS	Regional Centre for Groundwater Management in Latin America and the Caribbean
DIKTAS	Protection and Sustainable Use of the Dinaric Karst Aquifer System project
EU	European Union
FREEWAT	Free and open source tools for water resource management
GEF	Global Environment Facility
GGIS	Global Groundwater Information System
GGRETA	Groundwater Resources Governance in Transboundary Aquifers
GGMN	Global Groundwater Monitoring Network
GIN	Groundwater Information Network of Canada
GIS	Geographic Information System
GRIPP	Groundwater Solutions Initiative for Policy and Practice
GroundwatCH	Groundwater and Global Change - Impacts and Adaptation
GWdataCom	Capacity building for groundwater data collection and data management
HWRP	(WMO) Hydrology and Water Resources Programme
HYCOS	(WMO) Hydrological Cycle Observing System
HydroSOS	Global Hydrological Status and Outlook System
IAH	International Association of Hydrogeologists
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies of Colombia
IGAD	Intergovernmental Authority on Development
IGS	Institute for Groundwater Studies
IHP	International Hydrological Programme
IMS	Information Management System
INOWAS	Innovative web-based decision support system for water sustainability under a changing climate
ISARM	Internationally Shared Aquifer Resources Management
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
L/RBO	Lake/River Basin Organization
MAR	Managed Aquifer Recharge
MARVI	Managing Aquifer Recharge and Sustaining Groundwater Use through Village-level Intervention
MIM	Meta-Information Module (a GGIS component)
RIMS	Ramotswa Information Management System
SADC	Southern African Development Community
SADC-GMI	SADC Groundwater Management Institute
SAP	Strategic Action Plan
SDGs	Sustainable Development Goals
SOS	Sensor Observation Service
TBA	Transboundary Aquifer
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USGS	United States Geological Survey
WHYMAP	World-wide Hydrogeological Mapping and Assessment Programme
WINS	(UNESCO-IHP) Water Information Network System
WMO	World Meteorological Organization
WWQA	World Water Quality Assessment

1. SUMMARY

This is the report of IGRAC's activities in 2018, carried out according to the Work Plan 2018-2019 and in line with budgetary and personnel developments during the year. While 2017 was a year of consolidation for IGRAC, 2018 was marked by rapid expansion of activities and increase of IGRAC impact in general.

Capacity building was the main IGRAC project activity during the reporting year, also due to a large project on groundwater data collection and management, conducted for the fifteen SADC countries. After a period of low activities due to limited resources, groundwater monitoring received more attention again, revealing new opportunities for cooperation and development. Regional, transboundary groundwater assessment has remained one of the key thematic areas, chiefly thanks to re-established IGRAC involvement in long-term UNESCO-led projects. 2018 was also a year of successful building a case for invisible groundwater, either through innovative publications like a UN Groundwater Overview or trough a participation in important fora.

Most of IGRAC project activities were conducted in Southern Africa and Central and South-East Asia, with distinct increase of cooperation with governmental partners and NGOs in South America and USA.

With the renewed personnel, IGRAC started the year with reduced institutional memory but with enthusiasm and commitment to provide the high standard contributions to already on-going as well as planned activities. The merits of (necessary) investment in new personnel were already visible at the end of the reporting year: IGRAC has fulfilled all project obligations and initiated/conducted more activities than expected.

With the core funding arranged, new projects acquired, qualified personnel and good cooperation with the core partners, IGRAC had a very productive year.

2. IGRAC CONTENT ACTIVITIES

In 2018, IGRAC's content activities were carried out according to the Work Plan 2018-2019 and the resources (staff and budget) availability. The capacity building was the main activity, primarily because this was the main execution year of a large capacity building project in SADC, but also due some other activities such as groundwater governance training in Thailand. This was also a year of successful building a case for invisible groundwater, either through innovative publications like a UN Groundwater Overview or trough participation in important fora (World Water Forum, Rosenberg Forum, etc).

After a relatively low level of activities in 2017 due to lack of resources, groundwater monitoring activities were increased again, with new software development, data collection and broadening a cooperation. Aquifer assessment still played an important role among the activities but less than previous years. Groundwater quality was for the first time addressed after quite some time. IGRAC paid more attention to strengthening of existing collaboration networks (in SADC, IGAD, South-East Asia) and developing new ones (in Western Africa, Latin America). The main structure of IGRAC content activities remined unchanged:

- Global Groundwater Information System
- Global Groundwater Assessment
- Global Groundwater Monitoring Network
- Knowledge Sharing and Groundwater Governance

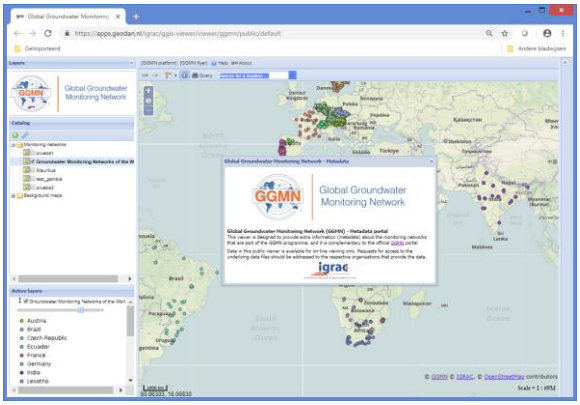
This chapter provides an overview of the main activities and their outcomes. Additional information is available in project documents and other IGRAC products and services, as referenced in the overview below.

2.1 GLOBAL GROUNDWATER INFORMATION SYSTEM (GGIS)

The GGIS is IGRAC's interactive web-portal to groundwater related information and knowledge. The main purpose of the GGIS is to assist in collection, storage and analysis of information on groundwater resources and its sharing among stakeholders such as water experts and decision makers. The system provides a global overview of aggregated information per country and per aquifer, detailed information about transboundary aquifers and managing aquifer recharge sites, and various regional groundwater data and information in tailor-made project portals. Software developed for monitoring within the GGMN application as well as IGRAC's other online databases are also considered a part of the GGIS. The map interface of the GGIS is complemented with a Meta-Information Module (MIM), where additional information and references are uploaded and linked to other data in the system.

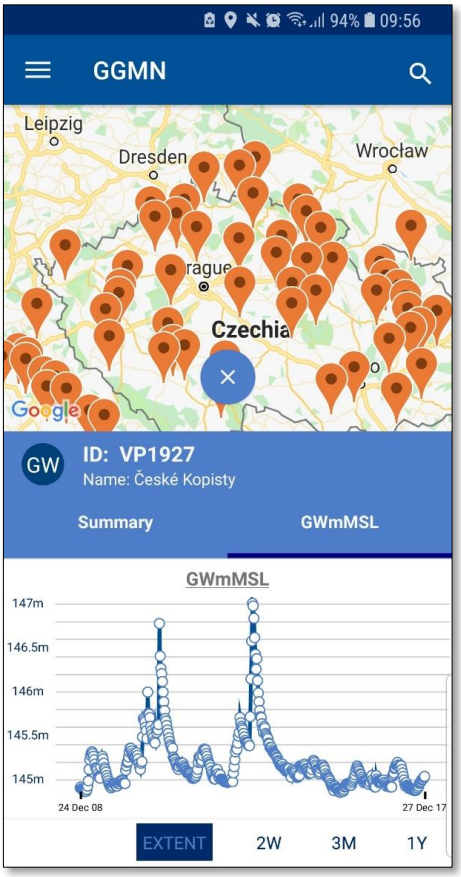
Software development

The main software development was related to groundwater monitoring, featuring two new functionalities: a GGMN OSS connection and a GGMN App.



Sensor Observation Service (SOS) is a web-based functionality that allows sharing of time-dependent data in a prescribed format. The main advantage of SOS connection is that data are truly shared, rather than exchanged. Moreover, it provides a direct, automatic update, ensuring actuality of data in the database. The SOS connection was first tested between the Canadian Geological Survey and USGS a couple years ago and this year the GIN (Groundwater Information Network of Canada) is connected with GGMN, since the SOS2.0 functionality is developed in the

GGMN portal. At this moment the data update is carried out once per week. The intention is to establish SOS connection with other national databases as soon as they develop the SOS functionality. This will enable a regularly updated overview of groundwater level change globally, as the main indication of quantitative state of global groundwater resources. In meantime, the established connection with the GIN will be used to demonstrate this service and promote data sharing.



GGMN App is a mobile phone application specially developed for monitoring of groundwater levels. A similar app MyWell was originally developed in a framework of an Australian project MARVI in India and now the same developer produced a customised version for GGMN. The GGMN App is easy to use and no knowledge of Excel and GIS is required any more to store data in GGMN. The app works also without internet (e.g. in remote areas), allowing the user to store data and upload those later when internet is available.

Some current functionalities of GGMN portal are improved as well: the time series portal was made more intuitive by reorganizing buttons, adding labels and synchronizing operations, info boxes are now visualised by mouse hovering, user manual is updated, etc.

A new viewer has been created in GGIS containing the locations and meta data of the monitoring wells stored in GGMN. This viewer is still under development, but it will be made public at the beginning of 2019. This is a step towards merging spatial and time-variant information in the GGIS software application as originally envisaged in 2014 but not implemented due to developer limitations at that time.

Since the life-time of the GGIS software will expire soon, the alternative to mitigate to open source database (such as PostgreSQL) is briefly explored. This also included checking harmonisation /complementarity with other public (UNESCO IHP-WINS, FREEWAT, WMO MCH) and commercial (e.g. KWR Menyanthes) software. Besides the handling of spatial and time-variant info, refurbishing of Meta Information Module (MIM) is considered, looking at possible synergies with the KINDRA database. Like the MIM, the KINDRA database serves to store and share groundwater literature but it is based on GeoNetwork open source software. This activity will continue and expand the next year.

Content update

The main content update was also in the GGMN portal, with many new monitoring data added (see the Groundwater Monitoring chapter). Other content additions are summarised in the table below and will be addressed in more details along other content activities in the following chapters.

Viewer	Updates
RIMS (Ramotswa-phase 2)	Map of land use South African borehole database (working document)
GIP (SADC-Groundwater Information Portal)	Groundwater drought risk maps Map with hyperlinks to BGS Africa Groundwater Atlas Map with hyperlinks to IMS in SADC Upload of documents in the MIM
MAR Portal	Update of the MAR global inventory
All	Satellite image added as background map

User support

As usual, IGRAC obtained in 2018 requests for data and information, mostly related to transboundary aquifers and groundwater monitoring. Some requests needed further clarifications and engagement, also a preparation of specific datafiles or maps. Most requests were from scientific community and consultancies. There were no requests for clarification of GGIS functionalities or remarks about its functioning.

2.2 GLOBAL GROUNDWATER ASSESSMENT

Generally, groundwater assessment activities at IGRAC include a country-based assessment, a transboundary aquifer (TBA) assessment and a thematic assessment. In 2003 IGRAC began aggregated country-based assessment but for a number of years TBA assessment was a major assessment focus, mostly due to large, GEF funded projects. That would have been the case for the last year as well if the approval/ start-up of some GEF project was not delayed. Thematic assessment in the reported year was confined to managing aquifer recharge and some quick scans of various topics.

Global Country-based Assessment

The most promising new assessment activity in 2018 is related to groundwater quality. Although IGRAC did some groundwater quality assessment in the past (arsenic, fluoride, saline & brackish groundwater), the vast majority of IGRAC activities are related to groundwater quantity. Therefore IGRAC prepared an overview of information available on emerging contaminants in groundwater as a possible topic for a global assessment. In meantime, UNEP announced a commence of a World Water Quality Assessment (WWQA) and IGRAC engaged with the partners (UNESCO-IHP, IAH, EAWAG, BGS, BGR, EU Groundwater Group, etc.) to prepare preferential topics for this assessment. IGRAC participated in a fruitful WWQA kick-off meeting where the groundwater was fully taken aboard: several proposals were made about the most urgent and feasible assessment including arsenic, fluorite, nitrate, microbiological pollutants and antibiotics. The final choice will also be determined by funding scheme, currently under development.

At the WHYMAP meeting in Paris (February 2018), IGRAC suggested revision of the Global Vulnerability Map to Floods and Droughts by involving additional parameters in calculation of vulnerability indexes or upgrading it into a risk map by introducing (e.g. climate change) projections. Subsequently, IGRAC scrutinized various assessment approaches it has used so far, in particular looking at the assessment specifics in regions vulnerable to climate change. Logical framework for an internal project Sustainability of Groundwater services in the Sahel under Climate change was prepared and so far (as a part of the framework) IGRAC conducted the extensive literature research. Sahel as a region was selected also because of anticipated World Bank project “Economic Growth and Water Security in the Sahel through Improved Groundwater Governance” where IGRAC’s contribution (together with UNESCO-IHP) is anticipated. The project is expected to commence in April 2019.

Transboundary Aquifer Assessment

Alike in 2017, the Ramotswa project was the only distinct transboundary aquifer assessment in 2018. Nevertheless, IGRAC contributed to several other transboundary project activities, such as GGRETA and DIKTAS. IGRAC also provided a key note at the AWRA “Conference on Transboundary Groundwaters” in Texas and continued to host and update the ISARM site.

Ramotswa Transboundary Aquifer Project

‘Ramotswa - phase 2: The Potential Role of the Transboundary Ramotswa Aquifer’ is a project led by IWMI and funded by USAID. In the phase 1, the project (2015-2016) focused on generating a solid base of knowledge on the aquifer in terms of hydrogeology and socio-economics. Phase 1 included setting up of the online Ramotswa Information Management

System (RIMS) by IGRAC, as well as a baseline assessment and improved mapping of the aquifer through an airborne geophysical survey.

IGRAC's role in the current phase 2 focusses on further developing the Ramotswa Information Management System. An important component is to 'institutionalise' the RIMS. This includes developing capacity of the national RIMS-managers so that they will be able to manage the system after the lifespan of the project.

In 2018, IGRAC contributed to a project workshop with more than 60 participants in Gaborone – Botswana (March 2018). This workshop was the '3rd Regional Meeting on Tools for the Sustainable Management of Transboundary Aquifers, 6-9 March 2018, Gaborone, Botswana', jointly organised by the RAMOTSWA-2, GGRETA-Stampriet phase 2 project (led by UNESCO-IHP) and SADC-GMI. In September 2018, IGRAC contributed to a RAMOTSWA-2 specific workshop in Pretoria, South Africa and IGRAC organised an additional training course for staff members from the Botswana Department of Water Affairs and the South African Department of Water and Sanitation who are involved in the management of the RIMS. The training covered an introduction to the GIS (using free software tool QGIS) and advanced features of the RIMS. IGRAC is currently working on a plan to ensure long term management and sustainability of the RIMS beyond the project's lifespan. Furthermore, the RIMS has been updated with some additional maps and data (see section on GGIS content update).

DIKTAS project

The first phase of the DIKTAS (Protection and Sustainable Use of the Dinaric Karst Aquifer System) project (http://diktas.iwlearn.org) was completed in 2015 and the kick-off meeting of for the second phase was held in Paris in May 2018 with contribution from IGRAC. However, the project (and the Project Document) is still in a preparation phase, led by UNESCO-IHP.

Very much related to the subject of the DIKTAS project were the Karst Summer School and the Symposium KARST 2018: Expect the Unexpected. This year, The Karst Summer took place in Trebinje (Bosnia and Herzegovina) and Virpazar (Montenegro). The course was attended by 14 participants from 5 countries, where the lectures were provided by seven international karst specialists, including one from IGRAC. This is already a fifth subsequent course in Trebinje, started as a DIKTAS project spinoff activity and continued thanks to support of several organisations including IGRAC.

This remarkable symposium KARST 2018 completely justified the use of the slogan "expect the unexpected": the key notes, the numerous scientific papers and the field trip, all of them vividly, through examples, reiterated the unpredictable nature of karst and challenges in understanding and managing karst groundwaters. The Symposium gathered about 150 participants from more than 20 countries. IGRAC contributed to the Scientific Committee and provided one of the keynotes.

The GGRETA project

The Groundwater Resources Governance in Transboundary Aquifers (GGRETA) project addresses issues related to transboundary aquifers and responds to the pressing need of increasing the knowledge on TBAs physical and socioeconomics characteristics. The project is funded by the Swiss Development Cooperation and executed by UNESCO-IHP. In the first project phase, IGRAC was responsible for data and information management and also provided technical support to the assessment of three transboundary aquifers among them the Pretashkent, shared between Republic of Kazakhstan and Republic of Uzbekistan.

In the second project phase, GGRETA is an effort towards a better integration of groundwater resources into the water management plans and operations, as a part of an approach to enable and foster international cooperation. Requested by UNESCO-IHP, IGRAC organised an expert meeting on development of a numerical model for the Pretashkent. It is believed that the model will improve understanding of groundwater regime and availability and assist in estimating/predicting the impact of human activities and climate change on the aquifer. This will allow better planning and management of groundwater resources, very precious for this region. The meeting took place in Tashkent in May 2018, kindly hosted by the State Committee of the Republic of Uzbekistan. After the meeting, the joined expert team prepared an overview of data availability and the needs for further development of the model. Further, the training programme on modelling and GIS is developed, to be executed at the beginning of 2019 in Delft.

Conference on Transboundary Groundwaters in Texas, USA

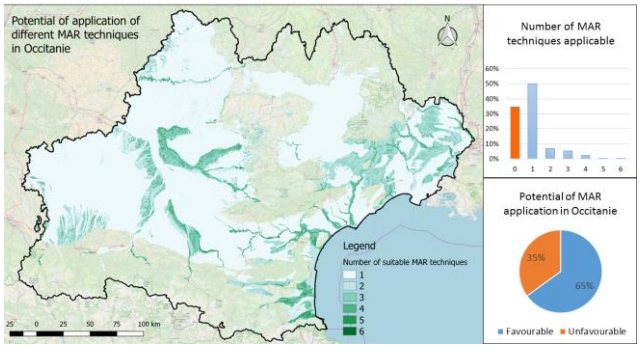
Among the TBA activities in 2018, the AWRA Conference in Fort Worth, Texas (July 2018) takes a special place, being the first international conference dedicated solely to TBAs since 2010 ISARM conference in Paris. The conference gathered experts from various disciplines (hydrogeologists, environmentalists, layers) presenting and discussing on behaviour of transboundary groundwaters and in particular about a governance framework required to sustainably use and ensure equitable access to this critical resource. IGRAC provided a keynote at the conference opening and participated in targeted discussion on Multidisciplinary Assessment of the Future of Transboundary Groundwater Science, Management and Governance. The intention is to use outcomes of discussion in developing a draft set of principles for identifying, studying and using transboundary groundwater resources.

Thematic Assessment

Thematic assessment was confined to managing aquifer recharge and some quick scans on solar-powered groundwater pumping, groundwater contribution to environmental flow, impact of climate change on groundwater quality and areal statistics for transboundary aquifers.

Managed Aquifer Recharge

The MAR Portal, developed by IGRAC and INOWAS, contains detailed information on about 1200 MAR sites from over 50 countries across the world. In 2018, new MAR sites have been added from Australia, Canada, Iran, New Zealand, Peru and Spain.



In addition to this global inventory of MAR sites, the portal also contains a selection of regional MAR suitability maps, which are developed to determine the most suitable places for implementing new MAR sites. In 2018, IGRAC carried out a research on MAR suitability mapping, with the support of an intern. The use of MAR suitability mapping was investigated in the Occitanie region (France). Various mapping methods were tested, and their results compared. This study provided insight on how to create meaningful MAR suitability maps. The main

conclusion is that the potential for MAR can be assessed over a given region using relatively simple maps, which can be created with a limited number of criteria. It is believed that such maps can adequately inform decision-makers and promote new applications of MAR.

Solar-powered groundwater pumping

A brief assessment of this topic was triggered by rapid implementation of solar pumping: in India, for example, there were 5,000 solar pumps installed in 2012 and over 170,000 today. This assessment was also a reply to a request to present the "emerging issues" during the groundwater governance training in Thailand and it was used in a project proposal Assessing Solar Pumped Groundwater to Enhance the Resilience of Food Production in sub-Saharan Africa (submitted in meantime). The overview of solar pumping is published as "a story" on the IGRAC website.

Other thematic quick scans

Occasionally quick thematic scans are made on external request or as a basis for decision making on further development. For example, IGRAC provided a comment to the guidelines over inclusion of the environmental flow for the calculation of the water stress in SDG6.4.2. Groundwater was not adequately represented and a comment (based on scan of topic in the guidelines and references) was necessary. Other examples are a quick scan of impact of climate on groundwater quality prepared for a WHYMAP discussion, and population & areal statistics for transboundary aquifers (for the latter see the ISARM site). The thematic scans of broader interest are published on websites, others remain as a foundation for further research, once commenced.

2.3 GLOBAL GROUNDWATER MONITORING

The Global Groundwater Monitoring Network is a participative, web-based network of networks, set up to improve quality and accessibility of groundwater monitoring information and subsequently our knowledge on the state of groundwater resources. GGMN is a UNESCO-IHP programme, implemented by IGRAC and supported by WMO.

In 2018, IGRAC added new functionality to GGMN (see Chapter 2.1), updated the content of the GGMN portal and expanded a monitoring cooperation, especially in Latin America.

Over the last year, a total of 16.318 new wells from 8 different countries have been added to the GGMN Portal. This includes data from Australia, Austria, Chile, Czech Republic, The Gambia, India, Spain and Switzerland. In addition, groundwater monitoring data for Brazil (29 wells), Germany (251 wells) and Sweden (180 wells) were updated in 2018.

Quest for new data led to establishment of new contacts and collaboration with organisations responsible for national groundwater monitoring in various parts of the world. Some national services provided IGRAC access to data, others (like the Czech Meteorological Survey) join actively, uploading their data in GGMN.

In April, IGRAC was invited to present GGMN at the 2nd Latin-American Symposium on Monitoring of Groundwater in Belo Horizonte, Brazil. In October, IGRAC participated in the 14th Latin American Congress of Hydrogeology, in Salta, Argentina. For this congress, IGRAC prepared a paper on the status of groundwater monitoring networks in Latin America, together with the Regional Centre for the Groundwater Management in Latin America and the Caribbean (CeReGAS). CeReGAS is, as well as IGRAC, a Category II UNESCO Centre and it is based in Montevideo, Uruguay. Its mission is to articulate national and regional capacities at public and/or private level for the sustainable management of aquifers and the protection of water resources. This common activity between two UNESCO centra initiated further talks about cooperation. Bringing together the global experience of IGRAC and the regional expertise and information accessibility of CeReGAS, could only be beneficial, was the conclusion. The perspective and intentions were subsequently elaborated and formalised in a Memorandum of Understanding. In November, IGRAC and the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) of Colombia have agreed (accompanied a formal letter exchange) to explore opportunities for collaboration in the field of groundwater monitoring. These potential activities would be part of the Global Groundwater Monitoring Network programme. This may include using the GGMN platform, capacity building or other groundwater-related activities.

IGRAC also participated in the WMO HydroSoS Conference and the UNECE Meeting Working Group on Monitoring and Assessment (both held in Geneva), urging for better inclusion of groundwater in monitoring activities. Envisaged involvement of IGRAC in the WMO HYCOS programme have not materialised yet, and in meantime Gambia joined Guyana in request to assist a national meteorological survey, conditioned by funding.

A global overview of national groundwater monitoring networks in under preparation, information from about 80 countries has been collected so far. WMO supported this activity by sending a formal letter to all member states. The purpose of the overview is information sharing, particularly about processing of collected data. The overview will be published in the first half of 2019.

2.4 KNOWLEDGE SHARING AND GOVERNANCE

Knowledge sharing is part of all IGRAC activities and involves creating networks of people and development of services for these networks. Some activities listed below can also be seen as thematic developments but they do not necessary include assessment. These activities are dedicated to groundwater governance and knowledge sharing beyond the groundwater management structure. In the chapter below, a distinction is made between predominantly governance activities, trainings & knowledge sharing activities and dissemination & outreach through publications, social media, events, etc.

Governance

Sustainable Development Goals (SDGs)

Since 2014 IGRAC has provided various inputs to the SDGs process, including position papers, articles the contributions to the indicators of the targets 6.3.2 (water quality), 6.4.2 (water stress), 6.5.2 (transboundary waters) and 6.6.1 (ecosystems). In 2018, the WWAP compiled the SDG6

Synthesis Report on Water and Sanitation 2018 and the Baseline monitoring reports for most of the SDG6 targets were drafted.

Requested by UNESCO-IHP, IGRAC participated in the technical meeting on SDG indicator 6.5.2, held in Budapest at the beginning of the year. Additionally, IGRAC supported the IAH participation at the at the meeting of United on SDGs held in Vienna in April. On behalf of the groundwater community the IAH president made an intervention about necessity of introducing a groundwater indicator in the SDG monitoring process. For the training in Thailand, IGRAC prepared a dedicated presentation on Groundwater Governance and SDGs. In December, IGRAC provided an intervention on contribution of groundwater to environmental flow in the SDG6.4.2.

Rosenberg Forum on Water Policy

Groundwater was in a focus of the tenth biennial Rosenberg International Forum on Water Policy held in October in San Jose, California. This prestigious forum gathered scientists and practitioners from all over the world to discuss a state of groundwater resources globally and challenges of development and implementation of policies for long-term sustainability of groundwater. IGRAC had a privilege to provide the only forum's keynote: Groundwater: Making Invisible Visible. The keynote addressed importance of building a case for invisible groundwater.

The Forum participants presented an impressive review of state-of the art techniques and the tools to better assess and manage groundwater resources. The Forum clearly revealed seriousness of groundwater situation in many regions throughout the world. The Forum also stressed the importance of IGRAC's mission in facilitating and promoting information and knowledge exchange for sustainable groundwater management. Since groundwater depletion is one of the main indicators of the state of groundwater resource, a proposal was made that IGRAC takes a role of a global clearing house for depletion data and prepares a global overview. Making groundwater a bit more visible.

UN Groundwater Overview: Making the invisible visible

IGRAC prepared a comprehensive overview of groundwater activities at UN-Water Member and Partner organisations. More than 30 organisations contributed to this document. UN Groundwater Overview showcases the essentials and the credentials of groundwater, placed within the broad spectrum of UN-Water Member's and Partner's activities. It is meant to inform about groundwater-related activities, to enhance knowledge exchange and collaboration, and to raise awareness about our most important hidden resource: groundwater.

United Nations agencies and programmes, together with their international partners, deal with many issues that involve groundwater: from wetlands to food production, from sanitation to climate change. Due to diversity and complexity of issues, it is often difficult to recognize a role of groundwater and adequately incorporate it in various decision-making processes. Understanding complementarities with other issues and using groundwater experience gained elsewhere is not easy either.

The overview presents interesting facts and figures, revealing diversities, resemblances

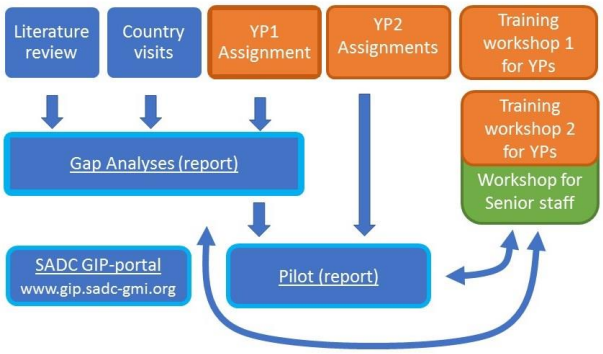
and complementarities in groundwater-related activities within the UN-Water Member's and Partner's community. It is helpful in understanding of connections of groundwater with health, migrations, tourisms, biodiversity, and many other vital segments of a human live. In this way, the overview is an additional incentive in taking joint actions across the (organisational, sectoral, administrative) borders, making the invisible groundwater a bit more visible.

The overview was launched a part of the World Water Day 2018 session at the World Water Forum in Brasilia with support of major global groundwater advocates namely UNESCO, IAH and GEF.

Knowledge Sharing and People Networks

SADC-GWdataCom project

In 2017 IGRAC was contracted by the SADC Groundwater Management Institute (SADC-GMI) for a project on Capacity building for groundwater data collection and data management in SADC Member States (SADC-GWdataCom project). The project started in September 2017 and will be concluded in April 2019. IGRAC is implementing this project together with the Institute for Groundwater Studies (IGS) of the University of the Free State (Bloemfontein – South Africa). The project has 3 distinct components:



Overview of project components

Component 1 – Analyses of current state of groundwater data collection and management

In the first phase of the project (Sept 2017 to early 2018) IGRAC and IGS made an inventory of current practices related to groundwater data collection and management in the SADC Member States based on literature review and interviews in 12 countries, with nearly 150 professionals involved in groundwater management and development. The inventory resulted in a gap analyses and recommendations to address the gaps in groundwater data collection and management. It also formed the basis for the capacity building component. Any data and reports collected in this phase of the project were also uploaded into the SADC-Groundwater Information Portal (SADC-GIP) which IGRAC set-up for SADC-GMI through a previous project in 2017. The SADC-GIP has also been improved by adding additional regional datasets (see section GGIS content updates).

Component 2 – Capacitating Young Professionals

In total, 26 young professionals from Member States were provided an opportunity to take part in the capacity building component of the project. Under the supervision of the IGRAC/IGS team, the young professionals worked on two assignments contributing to the project. They also took part in 2 training courses / workshops organised by IGRAC/IGS. The first one in May 2018 in Bloemfontein which allowed the team to combine classroom style lectures with field exercises using the experimental well site from IGS. The second training was organised in Johannesburg in November 2018. The courses and assignments contributed to developing their skills and to sensitize them on many aspects of groundwater data collection and data management. It also allowed them to build up their own international network of young groundwater professionals.

Component 3 – Pilot: Framework for groundwater data collection and management

Currently IGRAC and IGS are developing a Framework for groundwater data collection and management in SADC, which will be a document to assist and guide the Member States to improve groundwater data collection and management at national, transboundary and regional levels.

The 2nd training course for young professionals (November 2018) was combined with a workshop for senior staff members to receive their feedback on the GAP analyses report and the ideas for the framework. From this workshop IGRAC harvested many ideas first and all for uptake by SADC-GMI and the countries themselves, but also for potential IGRAC activities: e.g. to develop courses on how to turn data into information, and/or on the development of realistic monitoring programmes considering the practical challenges of limited budgets and limited dedicated observation boreholes.

In addition to the above activities per component, IGRAC presented and discussed project's progress at two meetings of the SADC-GMI steering committee (in March in Gaborone and in September in Johannesburg) and organised a special session during the 1st SADC Groundwater Conference, which included 2 presentations and facilitating a panel discussion between senior representatives of the SADC-secretariat and Member States.

AMBO project

A GEF project "Strengthening the institutional capacity of ANBO, contributing to the improved transboundary water governance in Africa" is approved this year. The project is structured around two main components:

- Strengthening ANBO's (African Network of Basin Organizations) institutional and technical capacity as a technical arm of the African Ministerial Council on Water (AMCOW)
- Supporting the capacity building of Lake/ River basin organizations (L/RBOs), Groundwater Commissions and Regional Economic Communities to foster transboundary cooperation

Together with UNESCO-IHP, IGRAC is in charge of integration of groundwater management in African Lake and River Basin Organizations (L/RBOs) and within the ANBO. GGMN and the GGIS will be applied to support ANBO and selected L/RBOs, i.e. ORASECOM and OMVS and to collect, share and process groundwater data and information. IGRAC will also provide a course on groundwater management for L/RBOs. This year, IGRAC took part to two preparation missions, one in Paris (France) in May, the other in Dakar (Senegal) in June and participated in the inception workshop in Dakar in November.

Training on Groundwater Governance for the Thai Department of Groundwater Resources (DGR)

In 2017 IGRAC organised a two-day programme including a field visit for a high-level delegation from Thailand, with managers from the Department of Groundwater Resources (DGR) and other related governmental departments & institutions. At the time it was discussed that as a possible follow up from this cooperation with DGR, IGRAC could provide a tailor-made training course on groundwater governance and monitoring in Thailand.

In 2018 DGR invited and contracted IGRAC to contribute to a three days training course on Groundwater Governance in July 2018. The course, which marked the end of a two-year DGR project on groundwater governance in Thailand was organised from 2-4 July in Bangkok. The course was attended by about 80 participants. Most participants were staff members of DGR (headquarters and regional offices), including both junior staff members and experienced staff members and even a previous minister and currently still a member of parliament. Other participants came from universities in Thailand. IGRAC contributed to the course with modules on an Introduction to Groundwater Governance; Groundwater Governance and the Sustainable Development Goals; Groundwater Management and Governance in the Netherlands; Groundwater Information Systems; Transboundary Groundwater Governance; and Emerging Issues in Groundwater Management.

Feedback from the participants was overwhelmingly positive, even to the degree that DGR asked a consent from IGRAC to translate some of the training modules into Thai language for further dissemination.

Groundwater Solutions Initiative for Policy and Practice (GRIPP)

GRIPP is an independent open global consortium of partners set up to connect, strengthen, expand and connect groundwater-related projects and initiatives. GRIPP was initiated by the International Water Management Institute (IWMI) and joined by many groundwater related organisations around the world. IGRAC is a core group partner next to IAH, IUCN, and a few other organisations.

During the World Water Week (WWW) in Stockholm, GRIPP organised a session "Groundwater-based natural infrastructure (GNBI) solutions: The missing link to resilience" where IGRAC presented advances of the MAR portal. Further, GRIPP was instrumental in dissemination of IGRAC products, like the UN Groundwater Overview. IGRAC provides and maintains an on-line archive for GRIPP partners.

IAH commission on Transboundary Aquifers

The IAH commission on Transboundary Aquifers was re-established in 2014 and IGRAC provides one of the co-chairs to the commission. IGRAC also provides additional support to the commission in terms of communications and maintains the commission's web-page and LinkedIn Group. Currently the LinkedIn Group has 178 members (status 17 December 2018) with regular postings from members with news on transboundary aquifer activities. The commission's webpage is set up by IGRAC under the ISARM website. As one of the commission's activities, IGRAC developed overviews of TBA related projects and literature, including the possibility for anyone to contribute additional references to the website.

Capacity building and education

IGRAC is associated partner in the Erasmus Master's Programme Groundwater and Global Change - Impacts and Adaptation (GroundwatCH) conducted by IHE Delft (the Netherlands), IST Lisbon (Portugal), and TU Dresden (Germany).

Like in 2017, IGRAC co-supervised a MSc student in this programme. This year, the supervised MSc research focused on investigating a decrease of groundwater levels in shallow hand-dug wells in Ouédo, southern Benin, assumed to be caused by the recent development of a new wellfield for urban water supply. IGRAC's interest in this specific topic stems from engagement in the NOEVA project in Benin and from providing a course on groundwater governance in Benin in 2017. The aquifer being studied is also part of a large transboundary coastal aquifer system and lessons from Benin can be exemplary for other urban areas in this densely populated coastal zone of west Africa.

In May, IGRAC provided a guest lecture to GroundwatCH students. Using examples from IGRAC activities, the lecture covered global aspects of groundwater from governance to assessment and monitoring, and including specific examples on transboundary aquifers. Also in May, groundwater from global perspective was introduced to a delegation of 15 water professionals from India. In June, four hours lecture on Managed Aquifer Recharge was provided to a group of 20 students in Innovative Water Systems for Agriculture. The lecture included an introduction to MAR techniques, an overview of MAR Portal functionality and MAR applications around the world, an introduction to MAR suitability mapping and exercises on selection of adequate MAR techniques for a real case study.

IGRAC took part in a peer review of the 6th edition of the UNEP Global Environment Outlook. In the first half of 2018, IGRAC provided various comments and short factual contributions on groundwater relevant aspects during the peer review process of the draft of the GEO-6 report.

Publications and communications

Publications:

- Nijsten, G.J., et al. 'Transboundary aquifers of Africa: Review of the current state of knowledge and progress towards sustainable development and management', Elsevier Science Direct.
- Sterckx, A., et al. 'Global groundwater demands' http://www.worldwateratlas.org/narratives
- Kukuric, N. Introduction to IGRAC, CAWater Yearbook (in Russian)
- Kukuric, N. 'DIKTAS: International Groundwaters of Dinarides', Proceedings the Karst Seminar Expect Unexpected, Trebinje, 2018.
- IGRAC 'UN Groundwater Overview: Making the invisible visible', UN Water publication, 2018.
- Cox, K. 'An investigation of decreasing groundwater levels in hand-dug wells in Ouédo, southern Benin', MSc thesis IHE Delft.
- Dupont, F. 'Managed Aquifer Recharge (MAR) - Suitability maps and standardized suitability index, the case study of the Occitanie region (South France)', IGRAC report.
- Dillon, P. et al (including N. Ansems). 'Sixty years of global progress in managed aquifer recharge' Hydrogeology Journal.

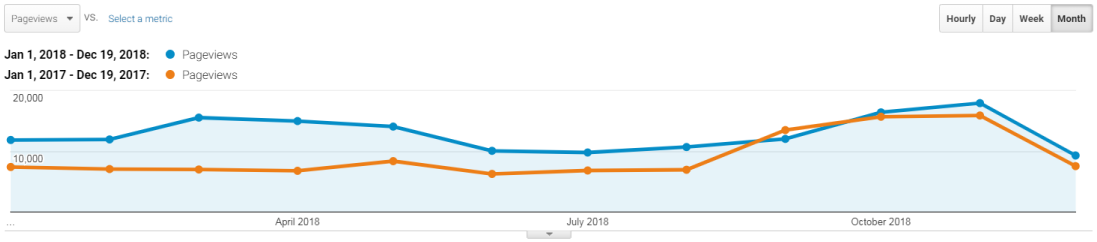
Communications

The website has undergone improvements in 2018, both content-wise and in terms of design and usability. On the content side, the main novelty was development of 'groundwater stories'. Since statistics from previous years shown that more in-depth news items were well read, stories about a specific topic or a region/country were introduced this year. Five stories are published so far, and the story about solar-powered groundwater pumping attracted most attention.

The design changes included a new homepage structure and design, a new GGIS page interface and restyling of the related resources and related pages blocks. A table below shows that the overall web performance has improved compared to last year.

Indicator	2017	2018	Change
Total sessions	44,556	72,418	+ 62%
Users	31,771	56,717	+ 79%
Pageviews	109,383	154,680	+ 41%
Average session duration	1:44 min	2:08 min	+ 19%

The example on the graph below shows that the increased number of pageviews per month continued the trend started in September last year.



Another interesting trend, started in 2017, is that IGRAC is attracting more attention in the Americas. In 2016, only about 26% of all visitors were from that region. In 2017, this already increased to 42% and, last year, it was even 51%. This increase started with translation of the web content in Spanish (as well as French and Russian) in 2016. In the past 12 months, the most popular page on the IGRAC website (even more than the homepage!) was: 'Qué es agua subterránea?'. This is, among others, a result of IGRAC's high ranking on Google for Spanish groundwater-related keywords.

In 2018, IGRAC dedicated more time to development of videos. A video announcing the launch of the Groundwater Overview at the World Water Forum) was viewed 1,721 on YouTube, Facebook, Twitter and LinkedIn combined. The video that promotes an information system (MAR Portal) was very popular, especially on Facebook, and received 6,700 views. The third was an in-depth interview with an IGRAC MSc student about her research; although quite long, this video attracted a total of 2,090 viewers. It seems that event announcement videos perform particularly well on LinkedIn, while short promotional videos do well on Facebook.

Following of IGRAC activities via social media is steadily growing: Below the number of followers per medium for 2017 and 2018.

Medium	2017	2018	Change
Facebook	19,338	31,596	+ 63%
Twitter	1,189	1,398	+ 18%
LinkedIn	490	508	+ 4%
Instagram	39	159	+ 308%

From May 2018, the new EU legislation (GDPR) has obliged every organisation with an e-newsletter service to ask e-newsletter subscribers to confirm their subscription. This invitation to re-subscribe to the newsletter was sent to all 929 EU citizens from IGRAC's mailing list, after which all those who did not respond had to be deleted from the list. Eventually, 239 contacts (26%) actively subscribed again. After enquiry among communication officers from several UN organisations, it appeared that this percentage is relatively high. The level of engagement also increased after this GDPR campaign, because the percentages for email opens and clicks gone up in recently sent newsletters.

Events (only non-project events)

- AWRA Summer Conference 2018 - Fort Worth, Texas, USA
- Rosenberg Forum on Water Policy, San Jose, California, USA
- UN-Water meetings Rome, Italy and Stockholm, Sweden.
- Karst 2018 Symposium - Trebinje, Bosnia & Herzegovina
- World Water Forum - Brasilia, Brazil
- Meeting on SDG 6.5.2 - Budapest, Hungary
- UNESCO IHP Region I Meeting - Delft, The Netherlands
- SADC-GMI Groundwater conference - Johannesburg, South Africa
- World Water Week - Stockholm, Sweden
- Water and Peace Seminar, Delft, The Netherlands
- Kindra Workshop - Brussels, Belgium

- WMO HydroSOS Conference, Geneva, Switzerland
- QGIS Users Day - Delft, The Netherlands
- II Latin American Symposium of Groundwater Monitoring - Belo Horizonte, Brazil
- XIV Latin American Congress of Hydrogeology - Salta, Argentina
- UNECE Working Group on IWRM and on Monitoring and Assessment - Geneva, Switzerland

3. INSITUTIONAL POSITIONING

According to the IGRAC Workplan 2018-2019, the focus of organisational activities will be *the strengthening of cooperation with key partners, preservation of IGRAC's institutional memory, and sustainability of IGRAC on longer period (from 2022 onwards)*. Looking at 2018, the focus was as planned and the outcome of activities positive, noting that long-term sustainability of IGRAC asks for increased attention in coming years.

Cooperation with UNESCO-IHP Secretariat has further increased in comparison with previous couple of years, with clear benefits for both parties. Following a decision of the IGRAC Governing Board, IGRAC director participated in the 56th session of the IHP Bureau and requested Bureau to consider which other UNESCO centre director(s) would like to participate and contribute to the Governing Board of the IGRAC. The Bureau took note and announced actions to follow up with the request. Together with IHE-Delft, IGRAC hosted a meeting of UNESCO IHP Region 1 centres and contributed to the meeting's presentations and discussions. On request of the UNESCO-IHP Secretariat, IGRAC represented UNESCO at the meeting on Sustainable Development goals in Hungary. Cooperation with CeReGAS, UNESCO regional groundwater centre for Latin America, resulted in a Memorandum of Understanding. IGRAC is actively contributing to implementation of the UNESCO's International Hydrologic Programme, in cooperation with UNESCO-IHP Secretariat and other partners. Involvement in externally funded projects implemented by UNESCO also increased, although not reflected sufficiently in the budgetary terms, meaning that IGRAC is using the core budget for these activities. Since IGRAC is set up to contribute implementation of the IHP, involvement in UNESCO-led projects is fully justified and appreciated at IGRAC. At the same time, IGRAC needs additional incomes (hence from projects) to be able to sustain.

Cooperation with WMO is carried out within the Hydrology and Water Resources Programme (HWRP). In 2018, IGRAC participated HydroSoS Conference advocating for groundwater monitoring. Further, WMO supported a preparation of the global overview of national groundwater monitoring networks by sending a formal letter to all member states. IGRAC still awaits involvement of GGMN in a Global Hydrometry Support Facility (HydroHub) development and in the WHYCOS programme. There are also requests for groundwater assistance from national meteorological surveys, being a subject to funding. IGRAC sees a cooperation with WMO as very good but limited; groundwater is one of the essential climate variables and IGRAC and WMO should explore ways to increase the attention to groundwater in climate change related activities.

Cooperation with UNESCO, WMO and other UN agencies is crucial for IGRAC; preparation of the UN-Groundwater Overview and its presentation during the WWD celebration at the WWF in Brazil, clearly pointed out an essential role of UN in advocating for (ground)water. UN-Water coordination mechanism proves to be very instrumental in bringing UN agencies and UN affiliated organisations closer in joint water-related activities. In 2018, IGRAC also started a collaboration with a number of partners in the framework of the World Water Quality Assessment, led by UNEP.

During the last year, IHE Delft and IGRAC – both UNESCO water centra – have been exploring possibilities for more extensive cooperation. So far, groundwater as a subject remains quite limited at IHE-Delft, especially when it comes to groundwater governance and diplomacy. Since governance and diplomacy and mostly supported by the Ministry of Foreign Affairs (MFA), it seems that both IGRAC and IHE-Delft need to increase efforts to bring groundwater on agenda at this ministry. Joint advocating for groundwater at MFA is also related to long-term sustainability of IGRAC centre (see further below).

IGRAC has developed a successful cooperation with SADC-GMI through a World Bank project in the region. There are on-going efforts to replicate a success of SADC-GMI in the Horn of Africa, where IGRAC could provide a similar support to one it does in the southern part of Africa.

IAH is the main partner of UNESCO-IHP and IGRAC in advocating for groundwater. IGRAC is IAH corporate member and last year IGRAC supported participation of IAH at two important events. Further, IGRAC participation in various IAH commissions (MAR, Karst, Transboundary

Aquifers, etc.) brings opportunities to establish and strengthen cooperation with many partners across the world.

In 2018, IGRAC invested a considerable effort to ensure preservation and continuation of centre's institutional memory. Due to uncertainly about the future of IGRAC and related budgetary instability in 2016, IGRAC personnel was reduced from 7 to the lowest of 3 (November 2017) with serious repercussions for the IGRAC's institutional memory. Since the financial situation in meantime improved (in particular due to successful acquisition in 2017), two new colleagues were recruited and successfully trained to conduct IGRAC activities. Nevertheless, the transition period between two financing periods of IGRAC showed that IGRAC does not have a critical mass (estimated to 7-10 FTE) to accommodate possible setbacks due to insufficient project acquisition and uncertainty of long-term funding. It is a humble opinion of the IGRAC staff that IGRAC water governance and water diplomacy activities deserve more attention of MFA and could be closely linked with similar (surface water) activities at IHE-Delft through a programmatic cooperation. It is, however, entirely to the IGRAC's Governing Board to determine the future of IGRAC, depending on ambitions and plans of its members. The meeting of the Governing Board (usually held towards the end of the year) is postponed on request of the Ministry of Infrastructure and Water (that provides the core funding) in order to (together with IHE-Delft) explore opportunities for more sustainable continuation of IGRAC from 2022. The IGRAC Foundation Board had its annual meeting in April 2018 and expressing its satisfaction with work of IGRAC and interest to more actively participate in discussions on long-term sustainability of the centre.

4. BUDGETING

4.1 Project Acquisition Activities

FUND / CLIENT	PROGRAMME / PROJECT	STUDY LOCATION	PARTNERS	STATUS APR 2019
EU	Copernicus evolution call LC-SPACE-04-EO-2019	World	GFZ – lead, several EU partners	Submitted
EU	PRIMA	Mediterranean region	Consortium of universities	Submitted
EU	Horizon2020 - India	India	IHE-Delft	Awarded, limited participation
USAID	Big data	SADC region	Umvoto, RSA	Awarded
US National Science	Assessing Solar Pumped Groundwater to Enhance Resilience of Food Production in Sub-Saharan Africa	Africa	University of Texas, IFPRI	Submitted
Adaptation Fund	Groundwater resources in the Greater Mekong Sub region; collaborative resource management to increase resilience	South-East Asia	UNESCO, IWMI, Country agencies, CCOP	Not awarded, re-submission in preparation
Partners voor Water	Dropbox for Water	Global, emphasis on Vietnam & Kenya	Nelen & Schuurmans, GIZ	Cancelled
Ministry of Water and Irrigation of Kenya	Groundwater Mapping - Kenya Wajir County	Kenya	GTK (Finland), DMT (Germany), SWAS (Kenya)	Not awarded
EU - INTERREG CE	Deepwater-CE	Central Europe	MBFSZ (Hungary) and several other European countries	Awarded, limited participation
SADC-GMI (World Bank)	Policy, Legal, and Institutional Development	SADC region	University of Strathclyde, FEI Consultants UNESCO	Not awarded
IGAD World Bank	Managing landscapes, Groundwater, and Natural Infrastructure for Resilience, Ecosystem Services and Livelihoods	IGAD region	GRIPP	Cancelled
WMO	Groundwater Monitoring – Guyana	Guyana	WMO	Awaits budgetary approval
World Bank	Sustainable Groundwater Knowledge and Governance in the Sahel	Sahel	UNESCO, OSS, FAO, IWMI	Proposal in preparation
GEF / UNDP	Kura River	Azerbaijan, Georgia	UNDP	Awarded
GEF / UNDP	GEF IW:LEARN - Strengthening IW Portfolio Delivery and Impact	Global	UNESCO	Awarded, limited IGRAC participation
SDC	GGRETA III - Groundwater Resources Governance in Transboundary Aquifers	Southern Africa, Central Asia, Latin America	UNESCO	Proposal in preparation
GEF / UNDP / ANBO	Strengthening the institutional capacity of African Network of Basin Organization (ANBO), contributing to the improved transboundary water governance in Africa	Africa (ANBO /AMCOW)	UNESCO	Awarded
GEF / UNDP	DIKTAS - Enabling implementation of the Regional SAP for the Dinaric Karst Aquifer System	South East Europe	UNESCO	Awarded
GEF / UNDP	SUMTAS - Fostering multi-country cooperation and conjunctive surface and gw management in the Bug River Basins and related aquifers	Eastern Europe	UNECE	Awarded, no IGRAC involvement
GEF / UNDP	NSAS - Enabling implementation of the Regional SAP for the sustainable management of the Nubian Sandstone Aquifer System	Northern Africa	UNESCO	Awarded, no IGRAC involvement yet
GEF / UNEP	Mediterranean Sea Program - Strategic actions for the protection of Mediterranean coastal aquifers	Mediterranean Region	UNESCO	Awarded, no IGRAC involvement

The project acquisition activities in 2018 remained at the level from 2017. A few projects were acquired solely by IGRAC, however with a limited budget (up to 30.000$) or covering only travelling expenses. Most of these projects will commence in 2019. UNESCO has involved IGRAC in a few larger projects (GGRETA, ANBO, DIKTAS), so far without budgetary benefits for IGRAC (partly due to delay in project execution). The specific expertise and role of IGRAC as a UN affiliated global centre remains the centre's main distinct value but also its main limitation to acquisition; IGRAC's "kind of activities" are almost exclusively funded by countries (either directly through their developing agencies or through international financial mechanisms) and almost exclusively executed through (accredited) UN agencies. Occasionally IGRAC can succeed to acquire a larger project on its own (like in 2017) but it needs assistance of its founding partners to retain the project turnover as high as in 2018 or to increase it further for the benefit of all stakeholders.

4.2 Financial Results 2018

The state of IGRAC's budgetary affairs at the end of 2018 is summarised in the table below. For comparison purposes, the overview for 2017 is provided as well. For each year, a Financial Statement Report (in Dutch) is produced by an external bureau for the IGRAC Foundation Board and it is available on request. Following the core funding requirements IGRAC has been financially audited by an independent accountant for 2016 and 2017 and it will be audited in 2020 for 2018 and 2019.

Budgetary items	**Year**	
	2017	2018
INCOMES		
Core funding	400,000	400,000
Projects and services	95,508	277,749
Bank account interests	435	
Total incomes	**495,943**	**677,749**
EXPENCES		
Direct project costs (exclusive wages)	25,220	172,113
Salaries and wages	233,992	283,653
Social security contributions	33,327	40,940
Pensions	34,225	39,226
Staff subcontracted (advisory, interns)	14,632	3200
Other staff costs	13,622	5623
Software & ITC costs	54,751	74911
Office rent	17,922	18,098
Office costs	9,510	6872
Depreciation	2,300	2494
General costs (insurance, fin. admin, etc.)	25,205	12,744
Bank account costs		-556
Total expenses	**464,706**	**659,874**
RESULT	**31,237**	**17,317**
Previous year balance	**292,567**	**323,804**
Equalisation reserves	**323,804**	**341,121**

International Groundwater Resources Assessment Centre