SDG6

Water Management

I. Introduction:

Water is the secret of life. Beni-Suef University is seeking always excellence in teaching, research and partnerships concerning water to help solving water crisis, to teach water related courses.

All evidences from the last years are sustainable and repeated periodically either in faculties or out of campus

Every event is available for all attendance free of charge for awareness

II. Teaching

Many faculties at BSU teach courses related directly to water +SDG4

Faculty fees per year for undergraduate student is 1000 L.E.

1-Faculty of science

http://www.science.bsu.edu.eg/

2-Faculty of earth science

http://www.earthsc.bsu.edu.eg/ContentSide.aspx?section_id=4023&cat_id=50

http://www.earthsc.bsu.edu.eg/Content.aspx?side_id=1611&cat_id=50

This is a unique undergraduate and postgraduate faculty at Beni-Suef University among all Egyptian universities

الأهداف الذهبية لقسم جيولوجيا المياه والبيئة – كلية علوم الارض

http://www.earthsc.bsu.edu.eg/Content.aspx?side_id=1612&cat_id=50

3-Faculty of Postgraduate studies for advanced sciences

This is a unique postgraduate faculty at Beni-Suef University among all Egyptian universities

Here are some of the courses related to water

#	Course	Program	Credit hrs
1	Clean Water Technology		1

2	Environmental chemistry and analysis	Diploma of Environmental Science and Industrial development	2+1
3	Water Reclamation Technology		1
4	Environmental Legislative Framework and Methods of Enforcement		1
5	Industrial wastewater technology		1
6	Monitoring and operation of wastewater treatment	Master of Environmental Science and Industrial development	1
7	Membrane science and technology		2
8	Basic hydraulics		2
9	Instrumental Techniques	Diploma and M.Sc. materials science and nanotechnology	2+1

Some examples of registered thesis related to water research

Master nano	**Fabrication of nanofiber Composite membrane for industrial waste water treatment**
	Preparation and Characterization of polymeric Nanofibers-Based Composites for Heavy metals Removal from Drinking and Ground water
	Synthesis and Characterization of depod TiO2- Graphene nano Composites for H2 Production from water
	spectroscopic investigation of semiconducting metal oxide nanoparticles in waste water treatment
	Nanocomposites for Arsenic Removal from Water
	The impact of Main Drains On Qarun Lake And Waste Water Treatment Using Polymer Nanocomposites
	Modified α-hematite nanostructures for photoelectrochemical water splitting

	Optical and Magnetic Properties of Metals Substituted Bismuth Iron Oxide Nanopowder for Water Treatment Application
	Synthesis and characterization of titanate nanotubes for heavy metals and organic pollutants removal from contaminated water
	Multifunctional perovskite nanomaterials for photoelectrochemical water splitting
Phd nano	**municipal wastewater treatment using carbon nanotubes-cellulose nanocomposite**
	application of nanotechnology for remediation of radioactive pollutants in water
	Developed Hybride Nanomaterials for Highly Efficient Catalytic Water Splitting

Phd environment	**Modelling of the Impact of Socio-Economic and Environmental alterations on Surface Water Quality**
	Assessment the risks and benefits of discharged alum drinking water treatment plants (DWTPs) sludge on water quality at Fayoum governorate, Egypt
Master environment	HEAVY METALS MONITORING IN WATER, SEDIMENT AND FISH FROM THE NILE RIVER AND THEIR HEALTH RISK ASSESSMENT ON HUMANS AT THE EAST REGION OF BENI-SUEF, EGYPT
	Wastewater purification using immobilized Nanophotocatalysts
	“Evaluation of drinking water quality using GIS: A case study in El Fayoum governorate-Egypt”
	Application of nanotechnology methods in industrial wastewater treatment as an environmentally friendly in industrial food sector
	Adress salinity wells and using the effluent for agriculture and live stock production

	Extracted oils from variant domestic wastewater microalgae communities as a source of biodiesel
	Using of algal free cells, treated and biofilms for Industrial waste water treatment
	study on the electrospinning of polymide fibers and its performance in waste water
	Potentials of Nano - activated carboon prepared from agricultural Wastes for removal of heavy metals from waste water
	Dual Applications of Duckweed in Wastewater Treatment and Biofuel Production
	Investigation of some environmental impacts of anthropogenic pollutants on River Nile water quality
	Determination, monitoring and risk assessment of selected pesticides in agriculture drain and Nile River, Assiut governorate
	Assessment of the artificially condensed water from atmospheric air as an untraditional water resource: a novel approach for sustainable development of rural and isolated areas
Master biotechnology	Optimization of algal biomass recovery using nanoparticles

http://www.psas.bsu.edu.eg/ContentSide.aspx?section_id=11742&cat_id=18

http://www.psas.bsu.edu.eg/Content.aspx?section_id=5745&cat_id=18

اللوائح الدراسية والمقررات الدراسية لقسم علوم البيئة والتنمية الصناعية

http://www.psas.bsu.edu.eg/Content.aspx?section_id=9278&cat_id=141

4- Faculty of agriculture (with a special department of water and soil)

http://www.agri.bsu.edu.eg/Departments.aspx?cat_id=23

http://www.agri.bsu.edu.eg/Content.aspx?section_id=10067&cat_id=23

5- Faculty of navigation science and space technology

http://www.spacescien.bsu.edu.eg/Sector_Home.aspx?cat_id=285

This is a unique undergraduate and postgraduate faculty at Beni-Suef University among all Egyptian universities

6- Faculty of Engineering

http://www.eng.bsu.edu.eg/Departments.aspx?cat_id=16

This year faculty of engineering will adopt the bylaws of Alexandria University and will open at the next year 2021 water engineering department

III. Research:

Separate report tracking research and projects concerning water is submitted yearly an example is appended

اللوائح الدراسية والمقررات الدراسية لقسم علوم البيئة والتنمية الصناعية

http://www.psas.bsu.edu.eg/Content.aspx?section_id=9278&cat_id=141

IV. Outreach and stewardship:

Centre of excellence in water research in cooperation with 5 Egyptian universities and 5 US universities funded from USAID

This centre has 5 pillars namely:

Exchange and training, education, governance, sustainability, research

Beni-Suef University is the co-chair for the sustainability phase

http://www.bsu.edu.eg/News.aspx?NID=95206&cat_id=1

https://www.egyptcoewater.eg/sustainabilty/ +SDG17

From the Government of Egypt, the project is supported by the Egyptian Ministry of Higher Education and Research, the Academy of Scientific Research and Technology, the Ministry of Water Resources and Irrigation, the Alexandria and Beni Sweif Governorates, the National Research Center, the Center for Metallurgical Research and Development Institute, the National Water Research Center, and the Water Desalination Alliance.

The Consortium of the project includes several prestigious US and Egyptian universities: University of California at Santa Cruz, Utah State University, Washington State University, Temple University, Ain Shams University, Aswan University, Beni Suef University and Zagazig University.

The consortium also includes a number of US and Egyptian private sector companies and NGOs: SEKEM Group, Lotus Company, Demerdash Group, Engazaat Development, and the NGO IBSAR, as well as AECOM, Amriton LLC, Apogee Instruments, Carollo Engineers, FREDsense Technologies, Purolite Corporation and Waters Corporation.

قافلة طبية للكشف المبكر عن الأمراض بشركة مياه الشرب ببني سويف+SDG3

https://www.bsu.edu.eg/News.aspx?NID=97783&cat_id=1

دبلومة رقابة الجودة قسم علوم البيئة- زيارة ميدانية - للشركة القابضه للمياه الشرب في مدينة بني سويف

https://www.bsu.edu.eg/News.aspx?NID=52972&cat_id=1

https://www.bsu.edu.eg/News.aspx?NID=49044&cat_id=1

Mediterranean cooperation on a PRIMA project with 10 partners and Beni-Suef University

https://www.era-learn.eu/network-information/networks/prima/section-2-call-2019-multi-topic/enhancing-diversity-in-mediterranean-cereal-farming-systems+ SDG17+SDG2

V. Cooperation and Partnerships

SDG17 +بروتوكول تعاون مع شركة مياه الشرب والصرف الصحي

http://www.bsu.edu.eg/Content.aspx?side_id=62&cat_id=1

SDG17+بروتوكول تعاون مع وزارة البيئة

http://www.bsu.edu.eg/Content.aspx?side_id=60&cat_id=1

مشاريع بحثية مع جامعة الأميرة نورة بنت عبدالرحمن بالمملكة العربية السعودية ممول بمبلغ قدره 171 ألف ريال سعودي أي ما يعادل 500 ألف جنيه مصري.

http://www.bsu.edu.eg/News.aspx?NID=26391&cat_id=1

وزير التعليم العالي ورئيس جامعة بني سويف والمحافظ يفتتحون البئر الاستكشافي للمساهمة في تنفيذ مشروعات زراعية بالجامعة

http://www.bsu.edu.eg/News.aspx?NID=64372&cat_id=1

http://www.bsu.edu.eg/News.aspx?NID=64327&cat_id=1

STDF funded project titled" Advanced removal of selected pharmaceutical residues from wastewater using nano-metal/organic frameworks (MOFs)"

اجتماع مجلس ادارة مركز الدراسات وابحاث المياه رقم) 3(

http://www.bsu.edu.eg/News.aspx?NID=73469&cat_id=1

علوم الملاحة وتكنولوجيا الفضاء في عيون الصحافة .. جريدة الوطن .. علوم الملاحة وتكنولوجيا الفضاء" تحسم جدل المياه الجوفية شرق النيل

http://www.bsu.edu.eg/News.aspx?NID=64425&cat_id=1

استاذ مساعد بعلوم بنى سويف يفوز بمشروع معالجة المياه ممول بمبلغ 595 ألف جنيهاً

http://www.bsu.edu.eg/News.aspx?NID=33805&cat_id=1

مجلس جامعة بني سويف يوافق على تبعية معهد تكنولوجيا المياه والبترول لجامعة بني سويف

طلبة حاسبات بني سويف ينجحون في تصميم فكرة شريحة يتم تركيبها علي عدادات المياه لقياس معدل الاستهلاك

http://www.bsu.edu.eg/News.aspx?NID=1237&cat_id=1

http://www.bsu.edu.eg/News.aspx?NID=10938&cat_id=1

http://www.earthsc.bsu.edu.eg/Backend/Uploads/PDF/%D9%85%D8%B7%D9%88%D9%8A%D9%87%20%D8%A7%D9%84%D9%85%D8%B1%D9%83%D8%B2-%D9%85%D8%AD%D9%88%D9%84.pdf

كليه علوم الارض تفوز بمشروعين بحثيين بتمويل قدره 80 الف جنيه

http://www.bsu.edu.eg/News.aspx?NID=61019&cat_id=1

رئيس جامعة بني سويف: فوز الجامعة بتمويل مشروع قدره مليون وستمائة وخمسين ألف جنيها من وزارة التعليم العالي

http://www.bsu.edu.eg/News.aspx?NID=60037&cat_id=1

رئيس جامعة بنى سويف: تمويل مشروع بحثي فى مجال معالجة المياة من أكاديمية البحث العلمي والتكنولوجيا

http://www.bsu.edu.eg/News.aspx?NID=60088&cat_id=1

رئيس جامعة بنى سويف فى زيارة لمشروع معالجة مياه الصرف الصحي بقرية البساتين بصحبة المحافظ والوفد الأمريكى

http://www.bsu.edu.eg/News.aspx?NID=59742&cat_id=1

جامعة بنى سويف تنفرد بتقديم مشروع بحثى متميز عن استخدام الخامات المصرية بدلاً من المستوردة فى مجال معالجة المياة

http://www.bsu.edu.eg/News.aspx?NID=56504&cat_id=1

رئيس جامعة بنى سويف : خطة لتوعية الطلاب بترشيد استهلاك المياة

http://www.bsu.edu.eg/News.aspx?NID=49313&cat_id=1

جامعة بنى سويف تطلق مبادرة " البيئة الخضراء" عن كيفية ترشيد المياة والمحافظة على البيئة

http://www.bsu.edu.eg/News.aspx?NID=60336&cat_id=1

SDG2+رئيس جامعة بنى سويف: ورش عمل عن استخدام تحلية المياة فى الاغراض الزراعية

http://www.bsu.edu.eg/News.aspx?NID=48763&cat_id=1

https://www.elfagr.com/3095202

https://cutt.ly/Se4Xqzk

https://www.elbalad.news/3388882

https://www.elwatannews.com/news/details/3725821

الأهداف الذهبية لقسم جيولوجيا المياه والبيئة – كلية علوم الارض

http://www.earthsc.bsu.edu.eg/Content.aspx?side_id=1612&cat_id=50

المشروعات الحالية لقسم جيولوجيا المياه والبيئة – كلية علوم الارض

http://www.earthsc.bsu.edu.eg/Content.aspx?side_id=1615&cat_id=50

مشروعات قسم علوم البيئة والتنمية الصناعية

http://www.psas.bsu.edu.eg/Content.aspx?section_id=420&cat_id=18

الابحاث لقسم علوم البيئة والتنمية الصناعية كلية الدراسات العليا للعلوم المتقدمة

http://www.psas.bsu.edu.eg/Content.aspx?section_id=5780&cat_id=18

SDG6+SDG7مشروع تسخين المياه بالطاقة الشمسية

https://www.bsu.edu.eg/News.aspx?NID=6392&cat_id=1

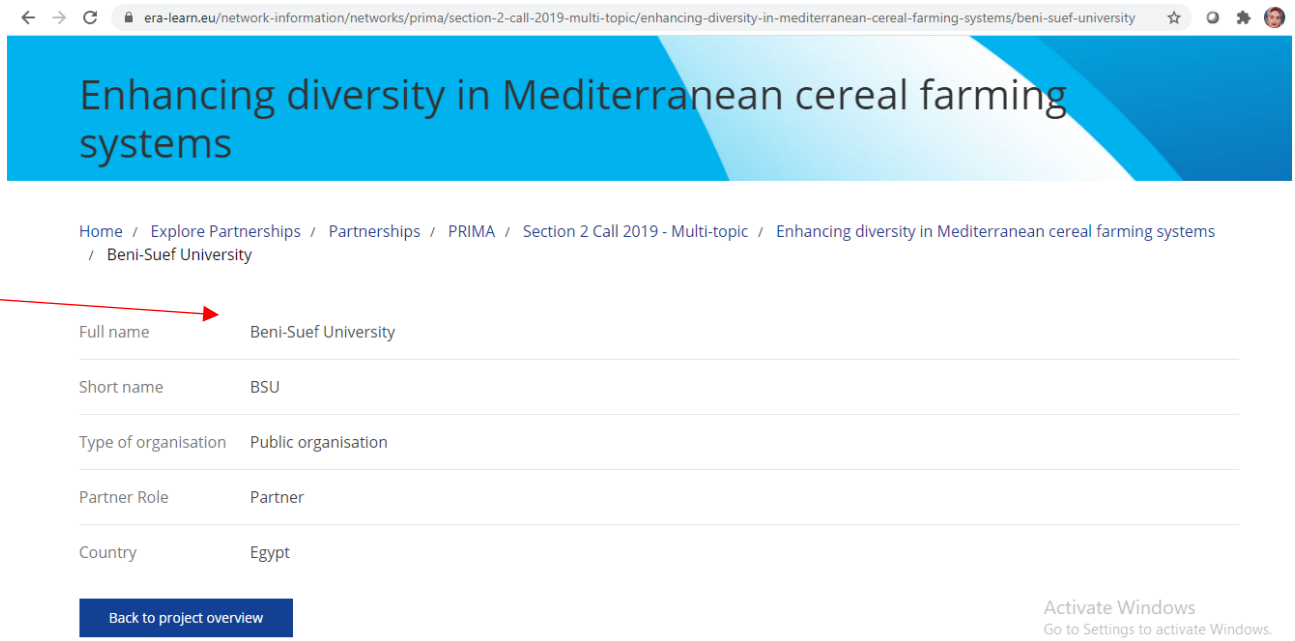
رئيس جامعة بني سويف : انشاء مركز تطوير وسائل المحافظة على البيئةSDG17+

https://www.bsu.edu.eg/News.aspx?NID=96324&cat_id=1

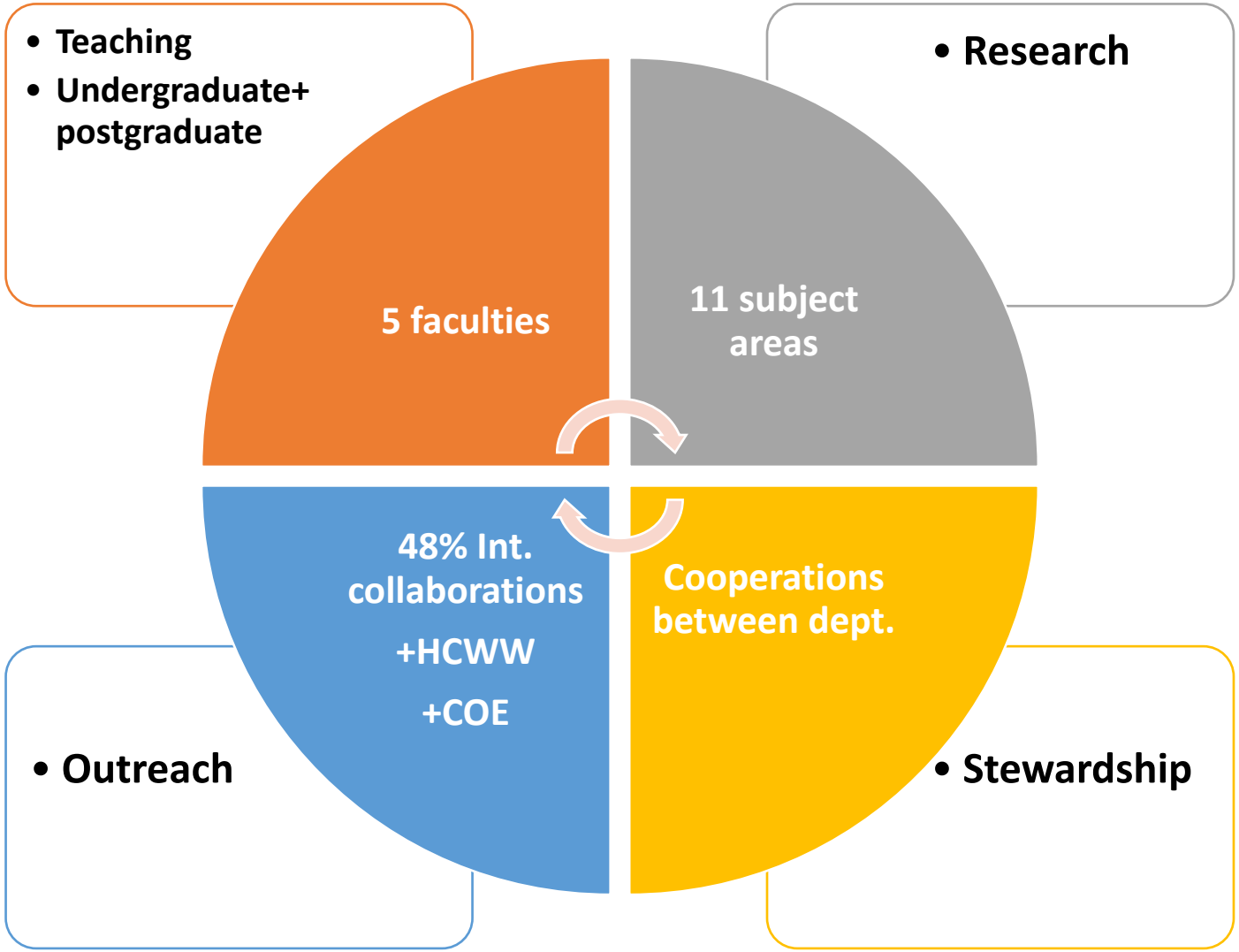
Some of the written protocols

- **المذكرة المعروضة من أ.د/عميد كلية علوم الأرض بشأن مقترح بروتوكول التعاون المشترك بين الكلية وشركة الغربية لمياه الشرب والصرف الصحي وذلك فى مجال الدعم الفنى والبحث العلمي وذلك على النحو المعروض .**
- **- المذكرة المعروضـــة من أ.د/عميد كلية علوم الأرض بشـــأن بروتوكول التعاون بين مركز التميز العلمي والتكنولوجي (وزارة الإنتاج الحربي) و كلية علوم الأرض (جامعة بني سويف) لتنقية المياة السطحية وتحلية مياة البحر ومعالجة مياة الصرف الصحى واعادة استخدامها من المشروعات التنموية بالدولة .**
- **بروتوكول تعاون بين جهاز مدينة بني سويف الجديدة هيئة المجتمعات العمرانية الجديدة ووحدة الاستشارات والدعم الهندسي والتكنولوجي بكلية الهندسة بخصوص قيام وحدة الاستشارات والدعم الهندسي والتكنولوجي بالإشراف على أعمال تنفيذ بعض مشروعات المياه والصرف الصحي والطرق ومباني الإسكان والخدمات بالمدن الجديدة .**

https://www.era-learn.eu/network-information/networks/prima/section-2-call-2019-multi-topic/enhancing-diversity-in-mediterranean-cereal-farming-systems
+SDG17+SDG2


era-learn.eu/network-information/networks/prima/section-2-call-2019-multi-topic/enhancing-diversity-in-mediterranean-cereal-farming-systems/beni-suef-university
Enhancing diversity in Mediterranean cereal farming systems
Home / Explore Partnerships / Partnerships / PRIMA / Section 2 Call 2019 - Multi-topic / Enhancing diversity in Mediterranean cereal farming systems / Beni-Suef University
Full name Beni-Suef University
Short name BSU
Type of organisation Public organisation
Partner Role Partner
Country Egypt
Back to project overview
Activate Windows
Go to Settings to activate Windows.

SDG6


• Teaching
• Undergraduate+ postgraduate
• Research
5 faculties
11 subject areas
48% Int. collaborations
+HCWW
+COE
Cooperations between dept.
• Outreach
• Stewardship

1-Faculty of science http://www.science.bsu.edu.eg/

2-Faculty of earth science http://www.earthsc.bsu.edu.eg/ContentSide.aspx?section_id=4023&cat_id=50 This is a unique undergraduate and postgraduate faculty at Beni-Suef University among all Egyptian universities

3-Faculty of Postgraduate studies for advanced sciences
This is a unique postgraduate faculty at Beni-Suef University among all Egyptian universities

4- Faculty of Engineering

5-Faculty of agriculture

#	Course	Program	Credit hrs
1	Clean Water Technology		1
2	Environmental chemistry and analysis	Diploma of Environmental Science and Industrial development	2+1
3	Water Reclamation Technology		1
4	Environmental Legislative Framework and Methods of Enforcement		1
5	Industrial wastewater technology		1
6	Monitoring and operation of wastewater treatment	Master of Environmental Science and Industrial development	1
7	Membrane science and technology		2
8	Basic hydraulics		2
9	Instrumental Techniques	Diploma and M.Sc. materials science and nanotechnology	2+1

SciVal

Overview | Benchmarking | Collaboration | Trends | Reporting | My SciVal | Scopus | 17 | SE

Egypt | More details on this Institution

2018 to >2021 | All subject areas | THE | Data sources

Summary | Topics | Rankings | Collaboration | Published | Viewed | Cited | Authors | Economic Impact | More...

+ Add Summary to Reporting | Export

Overall research performance

+ Add to Reporting

3,945 ▲
Scholarly Output
40.4% All Open Access
View list of publications

1,796 ▲
Authors

1.46
Field-Weighted Citation Impact
Yearly breakdown

25,494
Citation Count

6.5
Citations per Publication

60
h5-index

Activity of Beni-Suef University

Within: **SDG 6: Clean Water and Sanitation (2021)** | Year range used for metrics: 2018 to >2021 | Analyze Topic worldwide

Summary

+ Add Summary to Reporting

Performance

+ Add to Reporting

146

Scholarly Output

Chart with 5 data points.
The chart has 1 X axis displaying categories. Range: 5 categories.
The chart has 1 Y axis displaying values. Range: 0 to 58.

View list of publications

1.75

Field-Weighted Citation Impact

Chart with 5 data points.
The chart has 1 X axis displaying categories. Range: 5 categories.
The chart has 1 Y axis displaying values. Range: 0 to 2.21.

70

International Collaboration

Chart with 5 data points.
The chart has 1 X axis displaying categories. Range: 5 c
The chart has 1 Y axis displaying values. Range: 0 to 34

3,622

Views Count

1,439

Citation Count

Collaboration

+ Add to Reporting

International Collaboration

Publications co-authored with Institutions in other countries/regions

Beni-Suef University:
47.9%

Academic-Corporate Collaboration

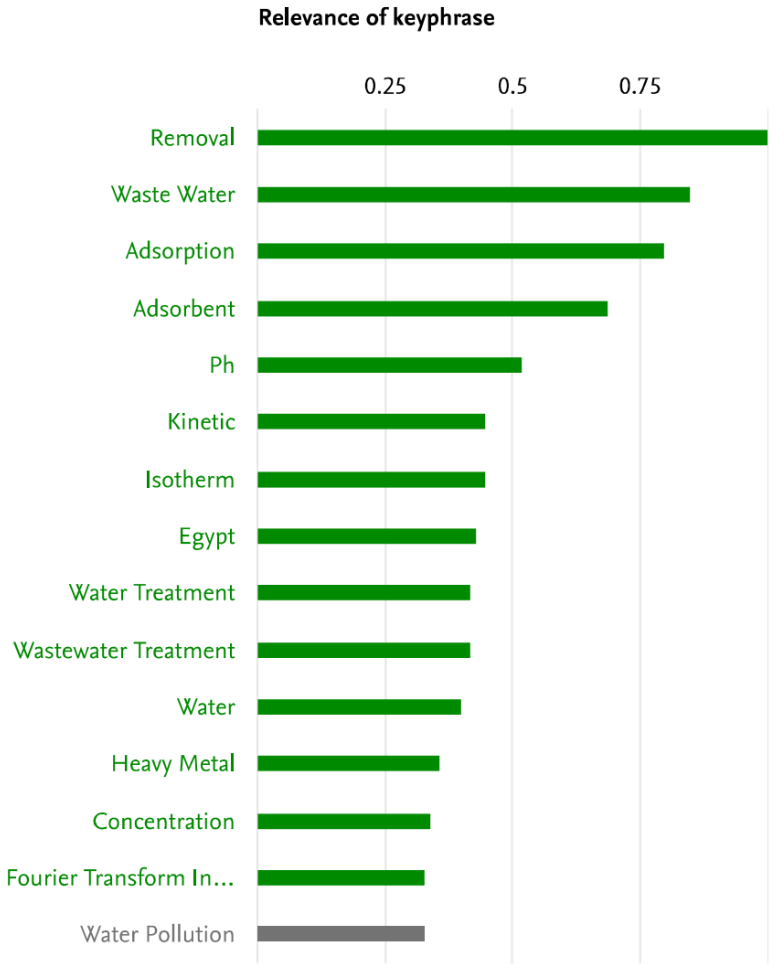
Publications with both academic and corporate affiliations

Beni-Suef University:
0.0%

Top 15 keyphrases

+ Add to Reporting

Based on 146 publications



declining A A A growing (2018-2020)

< Back to results

Export Print Email

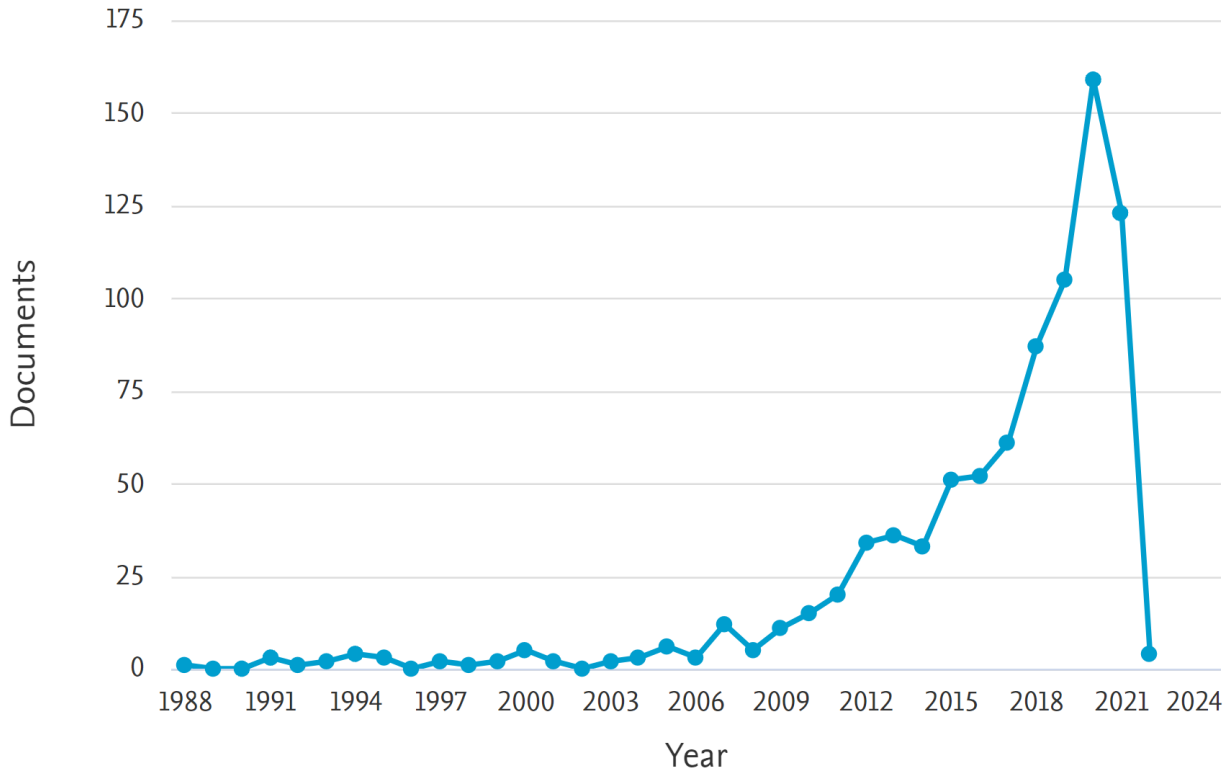
TITLE-ABS-KEY (water) AND (LIMIT-TO (AFFILCOUNTRY , "Egypt")) AND (LIMIT-TO (AF-ID , "Beni-Suef University" 60007948))

848 document results

Select year range to analyze: 1990 to 2022 Analyze

Year ↓	Documents ↑
2022	4
2021	123
2020	159
2019	105
2018	87
2017	61
2016	52
2015	51

Documents by year



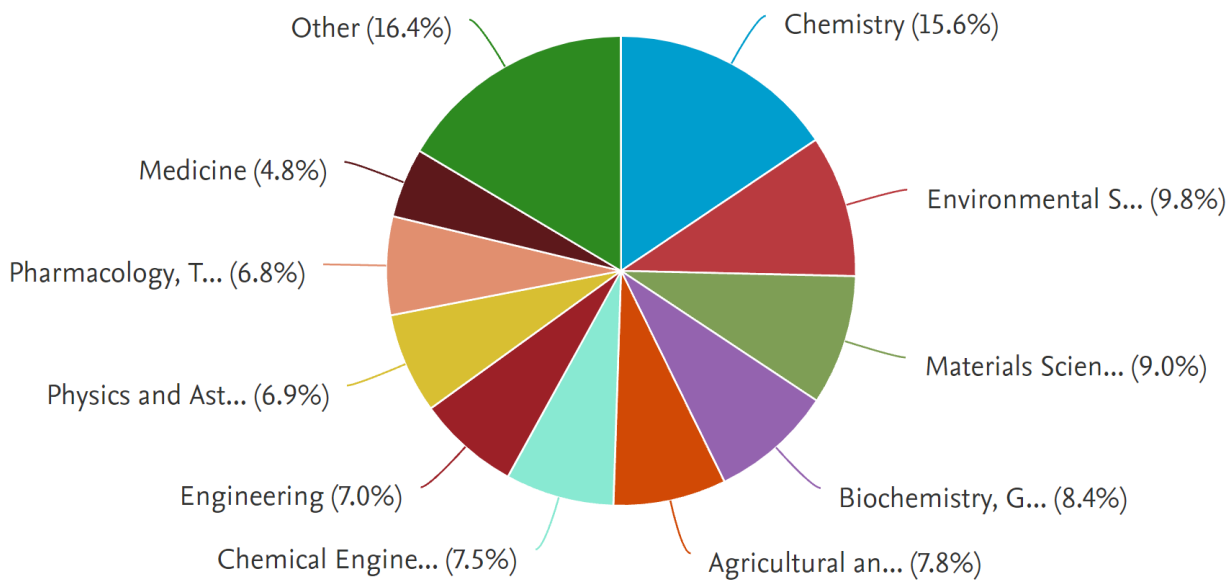
TITLE-ABS-KEY (water) AND (LIMIT-TO (AFFILCOUNTRY , "Egypt")) AND (LIMIT-TO (AF-ID , "Beni-Suef University" 60007948))

848 document results

Select year range to analyze: 1990 to 2022 Analyze

Subject area	Documents
Chemistry	250
Environmental Science	157
Materials Science	144
Biochemistry, Genetics and Molecular Biology	135
Agricultural and Biological Sciences	125
Chemical Engineering	120
Engineering	113
Physics and Astronomy	111
Pharmacology, Toxicology and	109

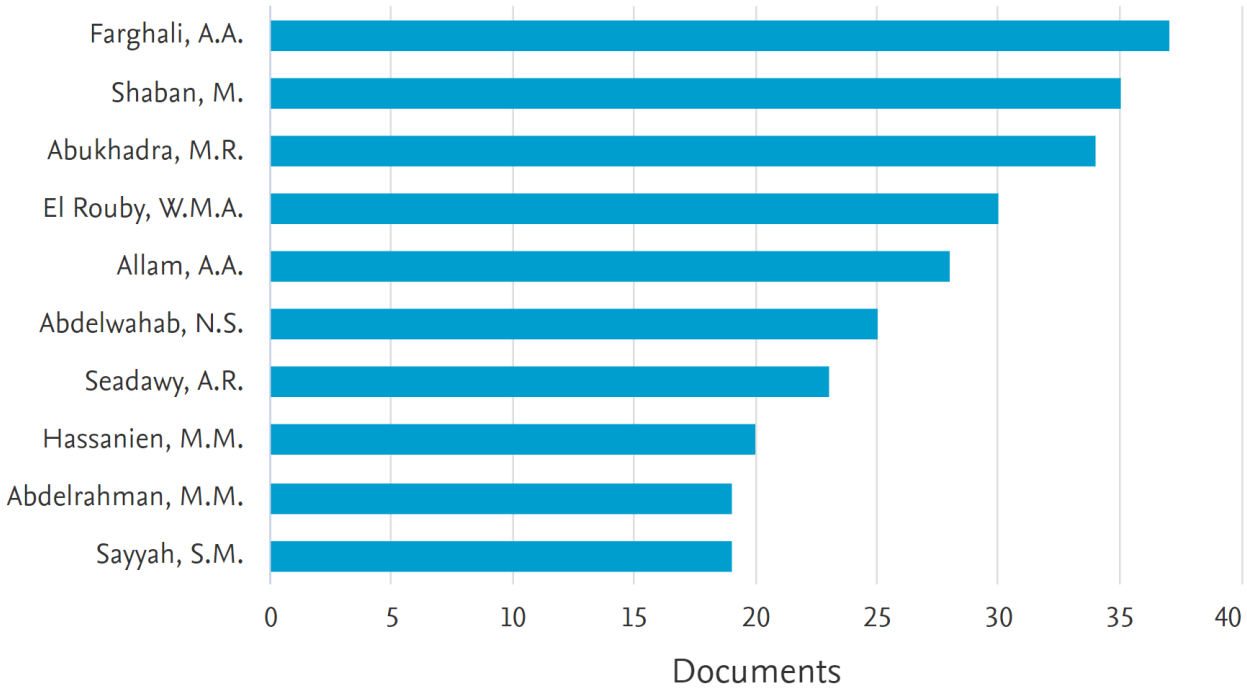
Documents by subject area



Author ↑	Documents ↓
Farghali, A.A.	37
Shaban, M.	35
Abukhadra, M.R.	34
El Rouby, W.M.A.	30
Allam, A.A.	28
Abdelwahab, N.S.	25
Seadawy, A.R.	23
Hassanien, M.M.	20
Abdelrahman, M.M.	19
Sayyah, S.M.	19

Documents by author

Compare the document counts for up to 15 authors.



USAID
FROM THE AMERICAN PEOPLE

THE AMERICAN UNIVERSITY IN CAIRO 100 YEARS

ALEXANDRIA UNIVERSITY

Center of Excellence for Water

WEBINAR

Final Session :Winter School on Water Energy Food Nexus and presentation of projects

Wednesday, December 9th, 11:00-12:30 AM Cairo Local Time (CLT)

The Water Energy Food Winter School:

The Water – Energy – Food Nexus (WEF) Winter School was held in a hybrid format of instructions (Online and Physical instructions) where attendees from Alexandria University, Ain Shams University, Beni Suef University, and Zagazig University were hosted by the American University in Cairo. During the 4 weeks hybrid instructions winter school, attendees were trained on comprehensive understanding of the interrelation existing among WEF Nexus, with the aim at educating researchers towards new thinking over sustainable solutions.

During the one hour and a half event, the three groups of the WEF attendees will present their final projects, all titled:

"Integration of Water Energy and food to increase sustainable access to services in a rural community"

Presentations of the attendees will include practical information about products they were able to produce during the Winter School and will be evaluated by a panel of experts from the Center of Excellence for Water.

Don't Miss Out – Join NOW

THE AMERICAN UNIVERSITY IN CAIRO 100 YEARS

This WEF Winter School is organized by the American University in Cairo

The Center of Excellence for Water is a USAID funded project aiming at creating a Center of Excellence for Water at Alexandria University– Egypt. The project is managed by the American University in Cairo (AUC) and has multiple partnerships and stakeholders

egyptcoewater | egyptcoewater | info@egyptcoewater.eg | www.egyptcoewater.eg | egyptcoewater | egyptcoewater

https://www.egyptcoewater.eg/download-category/newsletters/

USAID FROM THE AMERICAN PEOPLE

THE AMERICAN UNIVERSITY IN CAIRO 100 YEARS

ALEXANDRIA UNIVERSITY

Center of Excellence for Water

WEBINAR

Water and Sustainability

Tuesday, November 3rd, 2020 - 5:00-6:30 PM Cairo Local Time (CLT)

This webinar will:

- Begin with contrasting water sustainability with other goals for water management, including reliability, resilience, justice and security.
- List categories of action needed to achieve water system sustainability and provide examples.
- Provide practical examples of how they can be implemented in the Egyptian context.

Speakers:

Prof. Brent Haddad
University of California Santa Cruz - UCSC

Prof. Brent Haddad is a Professor of Environmental Studies at the University of California, Santa Cruz. He is the founding director of UCSC's Center for Integrated Water Management. His research covers water policy, economics, communications, and urban and regional water systems. He has published on water reclamation and reuse, desalination, interregional water transfers, water, and climate change, and other topics

Prof. Hani Sewilam
The American University in Cairo - AUC

Prof. Sewilam is currently the Academic Director of the Department of Engineering Hydrology and the Managing Director of the UNESCO Chair in Hydrological Changes and Water Resources Management at the RWTH Aachen University - Germany. He is a professor of water resources and sustainable development at the AUC. Main areas of specializations: Hydrology, water management, desalination and sustainable development. Prof. Sewilam established the M.Sc. program in "Sustainable Development" at the AUC; and the founder of the first Center for Sustainable Development in Egypt and the founding director of CARES.

Don't Miss Out - Click Here to Reserve Your Seat NOW

Suggested Audience: Graduate Students, Faculty, and Researchers, water system managers

This webinar is organized in cooperation with University of California Santa Cruz

The Center of Excellence for Water is a USAID funded project aiming at creating a Center of Excellence for Water at Alexandria University– Egypt. The project is managed by the American University in Cairo (AUC) and has multiple partnerships and stakeholders

egyptcoewater egyptcoewater info@egyptcoewater.eg www.egyptcoewater.eg egyptcoewater egyptcoewater

Disclaimer: The information provided in this webinar is not official U.S. Government information and does not represent the views or positions of the U.S. Agency for International Development or the U.S. Government

Outreach and stewardships

1- WRC cooperation with BSU
Beni-Suef University | State of Washington Water Research Center | Washington State University (wsu.edu)
2- course (curriculum developing)
Dr. Hamada... - The Center of Excellence for Water - Egypt | Facebook
3- USAID cooperation with BSU
Center of Excellence for Water | Egypt | U.S. Agency for International Development (usaid.gov)
4- Protocol with drinking water company
Cooperation Protocol with Sanitation and Drinking water Company (bsu.edu.eg)
5-https://www.egyptcoewater.eg/download-category/newsletters/

CENTER OF EXCELLENCE FOR WATER

THIRD PUBLIC PRIVATE PARTNERSHIP

THE ROLE OF PUBLIC PRIVATE PARTNERSHIP

(PPP)

IN SOLVING INDUSTRIAL WASTE WATER TREATMENT PROBLEMS

IN EGYPT

Dr. Samaa El Dek – Co-chair of the Sustainability pillar

COMPONENT 5: **SUSTAINABILITY**

Component Leader: **AUC**

Component Co-Leader: **Beni-Suef University**

Date: **2nd of September 2020**

Venue: **zoom online workshop**

(https://aucegypt.zoom.us/webinar/register/WN_8Qiq-5LERW2oNwStOHzkYw)

PREFACE

- **PPP** aims to encourage strong relationships with private sector partners which is essential to the long-term sustainability of the of the COE-Water activities.
- The current PPP is the third in series of the COE-Water and deals with the role of **PPP** in solving the Industrial Wastewater Treatment problems in Egypt.
- It is concerned with the discussion of the current and future challenges, innovative solutions and outlook for industrial waste water treatment in Egypt.

THE SPEAKERS

- **Dr. Farghali** introduced the successful models of research grants from Beni Suef that encourages the cooperation between academia and private sector.
- **Dr. Essam Shaban** spoke about the Center of Excellence for Water and explained the PPP inside the sustainability pillar of the system.
- **Eng. Ahmed El-Sehsah,** CEO - HCWW Beni Suef indicated the importance of the role of activation of the legislations in industrial wastewater and the integrated management of the problem and the role of the PPP in the solution.
- **Dr. Samaa El Dek** presented the relationship between the current workshop topic and the SDGs and the role of Beni Suef University.
- **Dr. Samar Mekkawi**, Head of Industrial Wastewater – HCWW Beni Suef gave a general presentation of industrial wastewater treatment in Beni Suef.

THE SPEAKERS

- **Eng. Hamdy salah,** Planet manager - Cleopatra cement company presented the wastewater treatment plant of his factory. He expressed his willingness to find a solution for anti-corrosive and dust treatment materials for the system.
- **Dr. Mohamed Mahmoud**, General Manager – Sanitation Reference Laboratory gave a general lecture on wastewater treatment and challenges.
- **Dr. Yehia Sherif**, Consultant and Industrial Wastewater Specialist indicated that HCWW does not perform industrial wastewater treatment and talk about the cooperation between HCWW with the private sector and the scientific committee.

MAIN RECOMMENDATIONS

- student's internships in HCWW for undergraduate and post graduate students for two or three weeks
- Facilitate filed visits for the students (under and postgrads) to the industrial sector to learn about the industrial wastewater treatment problems to begin industry need driven research
- Inclusion of industrial wastewater treatment in specific calls in the research program of the COE.
- Prof. Salah Bayoumi, Deputy CEO - HCWW Cairo, recommended that industrial watstewater problems should be included in the capacity building and information sessions in the field of water.

MAIN RECOMMENDATIONS

- HCWW should be involved in all projects targeting a design of wastewater treatment units to avoid future operation problems.
- Protection of water resources through:

- Enforcement of the law and prevent the waste connection
- The HCWW and relevant departments should intensify the tests and supervision on industrial sector
- Developing public awareness of the need to rationalize and better manage water resources

CENTER OF EXCELLENCE FOR WATER

THIRD PUBLIC PRIVATE PARTNERSHIP

THE ROLE OF PUBLIC PRIVATE PARTNERSHIP (PPP) IN SOLVING INDUSTRIAL WASTE WATER TREATMENT PROBLEMS IN EGYPT

SUMMARY AND RECOMMENDATIONS

COMPONENT 5: SUSTAINABILITY
Component Leader: AUC
Component Co-Leader: Beni Suef University
Date: 2nd of September 2020
Venue: zoom online workshop (https://aucegypt.zoom.us/webinar/register/WN_8Qiq-5LERW2oNwStOHzkYw)

Center of Excellence for Water
The American University in Cairo
AUC Avenue, P.O.Box 74 - New Cairo, 11835 - Egypt

The role of Public Private Partnership (PPP) in solving Industrial Waste Water Treatment problems in Egypt

Introduction/Summary

A Public Private Partnership (PPP) is an activity/initiative which engages the private sector (including corporations, foundations, and other non-governmental actors) as a core resource partner. Therefore, it aims at cultivating strong relationships with private sector partners which is an essential to the long-term success and sustainability of the of the COE-Water activities.

The current PPP is the third in series of the COE-Water and deals with the role of Public Private Partnership (PPP) in solving Industrial Waste Water Treatment problems in Egypt. The treatment of industrial waste water is becoming more and more critical to Egypt as it can increase the amount of water available for irrigation which is the major consumer of fresh water in Egypt with a share of about 80%.

The PPP is concerned with the discussing of the current and future challenges, innovative solutions and outlook for industrial waste water treatment in Egypt.

Main recommendations:

- Welcome notes from Dr. Samaa El Dek – Co-chair of the Sustainability pillar and Dr. Ahmed Farghali – Dean of Faculty of Postgraduate Studies for Advanced Sciences at Beni Suef University.
- Dr. Farghali introduced the successful model of research grants from Beni Suef that encourages the cooperation between academia and private sector.
- Dr. Essam Shaban made a presentation about the Center of Excellence for Water and situated and explained the PPP inside the sustainability pillar of the system.
- Major General Eng. Ahmed El-Sehsah, CEO - HCWW Beni Suef indicated the importance of the role of activation of legislations in industrial wastewater and the integrated management of the problem and the role of the PPP in the solution.
- Dr. Samaa El Dek presented the relationship between the current workshop topic and the SDGs and the role of Beni-Suef University.

- Welcome notes form the COP Dr. Yasser El Shayeb
- There was a recommendation for student's internships in HCWW for undergraduate and post graduate students for two or three weeks.
- Dr. Samar Mekkawi, Head of Industrial Wastewater – HCWW Beni Suef gave a general presentation of industrial wastewater treatment in Beni Suef.
- A recommendation to visit three factories and discuss their industrial wastewater treatment problems and begin industry need driven research
- Another recommendation is the inclusion of industrial wastewater treatment in specific calls in the research program of the COE
- The mobile industrial wastewater treatment unit is recommended as implementation /research topic also
- Eng. Hamdy salah shehata fergany Planet manager - Cleopatra cement company presented the wastewater treatment plant of his factory. He expressed his willingness to find a solution for anti-corrosive and dust treatment materials for the system.
- Dr. Mohamed Mahmoud Ismail, General Manager – Sanitation Reference Laboratory gave a general lecture on wastewater treatment and challenges.
- Prof. Salah Bayoumi, Deputy CEO - HCWW Cairo stressed on putting this event on several media tools.
- Prof. Bayoumi also indicated that capacity building and information sessions in the field of water in general and industrial wastewater in specific.
- It was agreed that the next meeting will be in the HCWW by Dr. Essam and Dr. Samaa
- Dr. Bayoumi also indicated that the HCWW is ready to host any pilot plant for water and wastewater coming from any research cooperation
- Dr. Yehia Sherif, Consultant and Industrial Wastewater Specialist indicated an important not is that HCWW does not perform industrial wastewater treatment but it has a scientific committee to evaluate these methods.
- Dr. Sherif also indicated that there is a cooperation between HCWW and private sector and the scientific committee
- The design of wastewater treatment without the input of HCWW is sometimes a common practice that lead to future operation problems.
- Dr. Sherif also stressed on the protection of the water resources:
    - Enforcement of the law and closing of the waste connection
    - The HCWW and relevant departments should intensify the tests and supervision on several factories
    - Information session to the public

  - Inviting related industry and general public to the HCWW and perform awareness raising campaigns.
- Dr. Mahmoud Gomaa from HCWW presented the career track of all employees of the company.
- Dr. Gomaa suggested the recommendation of certification/review of these training programs. The COE can form a committee to do so with the HCWW.

Center of Excellence for Water

Memorandum of Understanding
between
The American University in Cairo
and
Alexandria University
and
The Holding Company for Water and Wastewater

This Memorandum of Understanding (the "MoU") records the following understanding for collaboration between:

I. The American University in Cairo, located at AUC Avenue, 5th settlement, New Cairo 11835, Egypt. Represented in this MoU by Prof. Ehab Abdel Rahman in his capacity as Provost

Hereinafter referred to as (First Party or "AUC")

II. Alexandria University, located at 22 Elguish road, Elshatby, Alexandria, Egypt. Represented in this MoU by Prof. Essam Ahmed Elkordi in his capacity as President

Hereinafter referred to as (Second Party or "AU")

III. The Holding Company for Water and Wastewater is a duly organized company under the Presidential decree no. 135 for the year 2004, under the provisions of Egyptian Law No. 203 of 1991, with the place of business located at Courniche El Nil, El Sahel, Cairo, Egypt, P.O. Box 11231. Represented in this MoU by Eng. Mamdouh Raslan in his capacity as Chief Executive Officer (CEO).

Hereinafter referred to as (Third Party or "HCWW")

Each referred to as the "Party" and collectively referred to as the "Parties"

For the purpose of furthering cooperation, hereby affirm their intent to promote activities that will be of mutual benefit for their respective institutions, as per the following items:

- Acknowledging the announcement of the year 2019, as the year of Science by the Egyptian President;
- Realizing the importance of Water Research and Education for the Egyptian Landscape of Higher Education and Scientific Research;
- Capitalizing on the efforts of the United States Agency for International Development (USAID) to design jointly with the Ministry of Higher Education three Centers of Excellence to support Egypt's economic development in through partnerships for human and

institutional capacity building between higher education institutions in the United States and Egypt;

- Realizing the overall objectives of the Center of Excellence for Water as to substantially improve the capacity of Egypt's higher education institutions to drive public and private sector innovation, modernization and competitiveness, strengthen government policy to stimulate economic growth,

and contribute solutions to one of Egypt's development challenges.

1. PURPOSE:

The purpose of this MoU is to provide mutual assistance in the areas of research, education and exchange in support of the success and sustainability of the Center of Excellence for Water as to promote effective water resources management for the benefit of Egypt. In addition to institutionalizing the relationships between Parties, and identify roles and responsibilities of each Party within the framework of the USAID Cooperative Agreement awarded to the AUC for the establishment of the Center of Excellence for Water at Alexandria University.

2. OBJECTIVES:

First Party "AUC":

- Provide annual reports to AU and all partners / affiliated partners and companies regarding the activities and products of the Center of Excellence for Water.
- Act as a liaison between USAID, Center of Excellence for Water and all relevant parties in issues related to the project.
- Work with the administrative staff of the Center of Excellence for Water at Alexandria University to ensure the sustainability of the center beyond the lifetime of the project.
- Ensure proper dissemination of information, and the involvement of AU and HCWW in the project of the Center of Excellence for Water

Second Party "AU":

- Ensure the proper setup of the Center of Excellence for Water at Alexandria University.
- Legalize the incorporation of the Center of Excellence for Water within the University system.
- Provide all necessary administrative support for successful and sustainable Center of Excellence for Water functions during the lifetime of the project and beyond.
- Provide appropriate and sufficient space for the Center of Excellence for Water and its laboratory to ensure effective functioning.
- Support the Center of Excellence for Water with the needed staff and allow them to be released from University workload, while keeping university benefits.
- Host and implement, with other Egyptian Partner Universities, the developed curriculum.

- Provide, if necessary, lab facilities for Center of Excellence for Water research projects.
- Exploit all means to ensure sustainability of the Center of Excellence for Water beyond the lifetime of the project.

Third Party "HCWW":

- Participate in the development of Water related activities with emphasis on Public Private Partnership (PPP) based projects in addition to new developments of relevance.
- Participate in the various activities of the Center of Excellence for Water.
- Support applied research and entrepreneurships in the area of water and its applications in different fields and sectors by providing all capabilities to link the findings of applied research with the labor market and providing sustainable and practical solutions based on innovation and knowledge, through joint collaboration to support talented university graduates, provision of the necessary platforms and business incubators, support of young entrepreneurs, etc.
- Avail internship opportunities (not paid) to students and graduates of the Center of Excellence for Water.
- Cooperate with AU to create a sustainable model of operation for the Center of Excellence for Water.

3. OTHER PARTIES:

Other related entities, participating in similar activities referred to in this MoU, include all members of the consortium composed of:

- US Universities (AUC, Temple University, Utah State University, University of California at Santa Cruz and Washington State University);
- Egyptian Partner Universities (Ain Shams University, Alexandria University, Aswan University, Beni Suef University and Zagazig University);
- Egyptian Research Centers (Central Metallurgical Research and Development Institute, Desert Research Center, National Research Center and National Water Research Center);
- Egyptian Public Entities (The Ministry of Higher Education and Scientific Research, The Ministry of Water Resources and Irrigation, the Governorate of Alexandria, the Governorate of Beni Suef and the Academy of Scientific Research and Technology)
- Egyptian and US foundation and private sector (Engazaat Development, Lotus Organic Herbs & Spices, SEKM Group, Demerdash Group, IBSAR, Amriton LLC, Purolite Corporation, FREDsense Technologies Corp, Apogee Instruments, Carollo Engineer, AECOM and Waters Corporation)

4. NON-FUND OBLIGATING DOCUMENT:

This MoU merely constitutes a statement of the mutual intentions of the Parties with respect to its contents and does not constitute any obligations binding on any parties. A definitive agreement (or agreements) regarding any projects, activities or programs contemplated hereby will be concluded between the Parties.

5. LIAISON:

Each Party will nominate an academic contact and/or a Program Coordinator who will communicate regularly with his/her opposite number to monitor the progress of collaboration.
Please enter designated contacts for each Party

1. From AUC side: ***Prof. Yasser Elshayeb***, yasser.elshayeb@aucegypt.edu, +20 2 2615 1715
2. From AU side: ***Prof. Hesham Gaber***, hgaber@alexu.edu.eg, +201223452749
3. From HCWW side: ***Dr. Mohamed Mahmoud Ismail***, mohamoh.ismamail@yahoo.com, +20127 0000572

6. COMPLIANCE:

The parties agree to be bound by their applicable rules governing equal employment opportunities, nondiscrimination and protecting the welfare of the beneficiaries of this MoU as well as their respective communities.

7. LIABILITIES:

It is understood that no party is the agent of the other and is not liable for the wrongful acts or negligence of the others. Each party shall be responsible for its negligent acts or omissions and those of its officers, employees, agents or students (if applicable), however caused, to the extent allowed by their respective country laws.

8. CONFIDENTIALITY AND IP RIGHTS:

AUC, AU and HCWW guarantee and hereby confirm that they shall not release, utilize, or publish any data that would be acquired during the course of this MoU without prior written consent of all Parties legal representatives.

9. DURATION AND VALIDITY:

This MoU and all future agreements made as a result of this MoU will be subject to the rules and regulations governing AUC, AU and HCWW.

No Party will take action relative to this MoU without consultation with the other Parties. Details of any further collaboration will be negotiated between the Parties prior to the signing any agreement for any initiative/project/proposal/deliverable/etc. The duration of this MoU is three years, and is subject to revision, renewal or cancellation by joint consent and becomes effective upon completion of signature.
Each party may terminate this MoU by written notification signed by the appropriate official of the party's institution initiating the notice. Notification of termination should be received by the other party at least three months prior to the effective date of termination, although

it is assumed that such action would only be taken after consultation in order to avoid any possible inconvenience to the other parties.

10. GOVERNING LAW AND JURISDICTION

That it is to all parties' mutual benefit to resolve their differences or dispute amicably. Accordingly, all agree to contact the other's designated representative to discuss and work toward the resolution of any disputes which may arise during the term of this Agreement. The parties agree that each shall indemnify, defend, and hold harmless the other party for any loss, claim, damage, or demand, whether real or personal property damage resulting from their negligence or the negligence of their officers, directors, agents, employees, or subcontractors. No consequential, liquidated or special damages may be claimed against the other party.

This MoU shall become effective upon completion of signatures by all Parties, on September 22, 2020.

In witness thereof, the responsible parties hereto offer their signatures

THE AMERICAN UNIVERSITY IN CAIRO	ALEXANDRIA UNIVERSITY	HOLDING COMPANY FOR WATER AND WASTEWATER
_____	_____	_____
Name: Prof. Ehab Abdel Rahman Title: Provost	Name: Prof. Essam Ahmed Elkordi Title: University President	Name: Eng. Mahmoud Raslan Title: Chief Executive Officer
		_____ Name: Eng. Salah Bayoumi Title: Deputy Chief Executive Officer

The Center of Excellence for Water

NATIONAL WATER RESEARCH ROADMAP

Version 1 - 2021

In partnership with

Table of Contents

Table of Abbreviations 5

1 Introduction 7

2 Rationale behind the NWRR 9

3 The Development of the NWRR 10

3.1 Water Challenges Facing Egypt 12

3.1.1 Literature review to identify water challenges 12

3.2 Process of Identifying Topics Requiring Water Research in Egypt 14

3.2.1 Research Needs Analysis Campaign 14

3.3 Water Strategies Adopted by Different Ministries in Egypt 17

3.3.1 Ministry of Water Resources and Irrigation 17

3.3.2 Ministry of Agriculture and Land Reclamation 17

3.3.3 Ministry of Higher Education and Scientific Research 17

3.3.4 Ministry of Trade and Industry 17

3.3.5 Ministry of Environment 17

3.4 Human and Infrastructure Constraints 19

3.4.1 Human Resources Constraints 19

3.4.2 Infrastructure Constraints 19

3.5 Identified Water Challenges in Egypt: Identifying Topics 22

Topic 1: Water Scarcity 24

I. Water Use Efficiency 24

II. Non-conventional water resources 24

Topic 2: Climate Change 24

III. Vulnerability, adaptation, and mitigation of sea level rise 24

IV. Temperature Increase and Hydrological Changes 24

Topic 3: Transboundary Water 24

V. Transboundary River 25

Topic 4: Sanitation 25

VI. Safe treated wastewater reuse 25

VII. Centralized/Decentralized Wastewater Treatment 25

Topic 5: Aquaculture Sustainability 26

VIII. Increasing Fish Productivity per unit Water 26

IX. Integrated Aquaculture Systems 26
Topic 6: Water Quality 26
X. Industrial Wastewater Management 26
XI. Remediation and Rehabilitation of Water Bodies 26
Topic 7: Water Management in Egypt 26
XII. Farm Water Management/Irrigation Modernization 26
XIII. Integrated Water Resources Management 27
Topic 8: Water Economics 27
XIV. Water Allocation 27
XV. Water Use Incentives 27
3.5.1 Connections Between the Research Topics 27
3.5.2 Assessment of the Impact of Identified Research Topics on Egypt's Social, Economic and Environmental Conditions 31
3.5.3 Discussion on Identified research topics and their relative weight (prioritization) 35
3.5.3.1 Models of Collaboration and Public-Private Partnerships 35
3.5.4 Validation through Consultation on the NWRR 37
3.5.5 National Consultation Workshop (3-6 March 2021) 37
3.5.6 Proceeding and Prioritization 38
3.6 Conclusions and list of priorities for the Center of Excellence for Water 40
4 How to use the NWRR document 41
4.1 Objectives of the first version of the NWRR 41
4.2 NWRR Review and Update Mechanism 41
5 List of Contributors to the NWRR document 42
5.1 From the Center of Excellence for Water (in Alphabetical Order) 42
5.2 Members from the Research and Policy Committee (in Alphabetical Order) 42
5.3 Experts for consultation / review on the NWRR draft (in Alphabetical Order) 42
6 References 44
7 Annex I: Literature Review of Water Challenges in Egypt 45
Topic 1: Water Scarcity 45
Topic 2: Climate Change 46
Topic 3: Transboundary Water and Water Security 47
Topic 4: Sanitation Coverage 47
Topic 5: Aquaculture Sustainability 48
Topic 6: Water Quality 49

Topic 7: Water Management in Egypt 50
Topic 8: Water Economics 51
7.1 References 52
8 Annex II: Research Needs and Capacity Report 55
8.1 Executive Summary 56
8.2 Introduction/ Background 56
8.3 Methodology 57
8.4 Survey Template (Questionnaire) 57
8.5 Study Results and Findings 59
8.6 Additional Findings from Site Visits 61
8.7 Acknowledgements 62
9 Annex III: Training Needs Assessment Report 63
9.1 Introduction/ Background 64
9.2 Methodology 64
9.3 Study Findings 64
9.3.1 Professor/Academic Skills Need Survey 64
9.3.2 The Research Capacity Analysis Survey 66
9.3.3 Non-Academic Organization Needs Analysis Survey 68
9.4 Additional Findings from Site Visits 69
9.5 References 69
10 Annex IV: NWRR Change Request 70

Table of Abbreviations

Term/ Abbreviation	Description/ Definition
ASRT	Academy of Scientific Research and Technology
ASU	Ain Shams University, Egypt
ASWU	Aswan University, Egypt
AU	Alexandria University, Egypt
AUC	American University in Cairo, Egypt
BSU	Beni Suef University, Egypt
CMRDI	Central Metallurgical Research and Development Institute
DRC	Desert Research Center
EEAA	Egyptian Environmental Affairs Agency
EPU	Egyptian Partner Universities
GCMs	Global Circulation Models
IWRM	Integrated Water Resources Management
MoALR	Ministry of Agriculture and Land Reclamation
MoE	Ministry of Environment
MoHESR	Ministry of Higher Education and Scientific Research
MoHP	Ministry of Health and Population
MoHUUC	Ministry of Housing, Utilities, and Urban Communities
MoTI	Ministry of Trade and Industry
MoU	Memorandum of Understanding
MoWRI	Ministry of Water Resources and Irrigation
NAS	Nubian Aquifer System
NWRC	National Water Research Center
NWRR	National Water Research Roadmap
OFWM	On-farm Water Management
PAC	Project Advisory Committee
PPP	Public-private Partnership
RAS	Recirculating Aquaculture System
RES	Rock Engineering Systems
RI	Research Institutions
RPC	Research and Policy Committee
SCU	Supreme Council of Universities
SDG	Sustainable Development Goals
SLR	Sea Level Rise
STDF	Science and Technology Development Fund
TU	Temple University, U.S.
U.S.	United States of America
UCCD	University Career Centers Development Project
UCSC	University of California, Santa Cruz, U.S.
UN	United Nations
USAID	United States Agency for International Development
USU	Utah State University, U.S.
WSU	Washington State University, U.S.
ZU	Zagazig University, Egypt

1 Introduction

The Center of Excellence for Water is a major project funded by the USAID in 2019, to address a critical challenge in Egypt, consistent with Egypt's *Vision 2030* document. The Grant, awarded to and managed by the American University in Cairo (AUC), establishes a Center of Excellence-Water at Alexandria University, Egypt, in cooperation with several partners and stakeholders (Universities, Public Institutions, and Industries - illustrated in Figure 1). The Center of Excellence's goal is to catalyze long-term improvement in Egyptian water resources management by developing an innovative applied research and education enterprise. The duration of the project is 5 years, beginning February 20th, 2019, and the total allocated budget is $30 Million USD. The project will fund 40 Research Projects, 12 new Undergraduate Courses, 4 new Professional Certificate programs, 18 new Post Graduate Courses, and will also fund 350 academic exchanges.

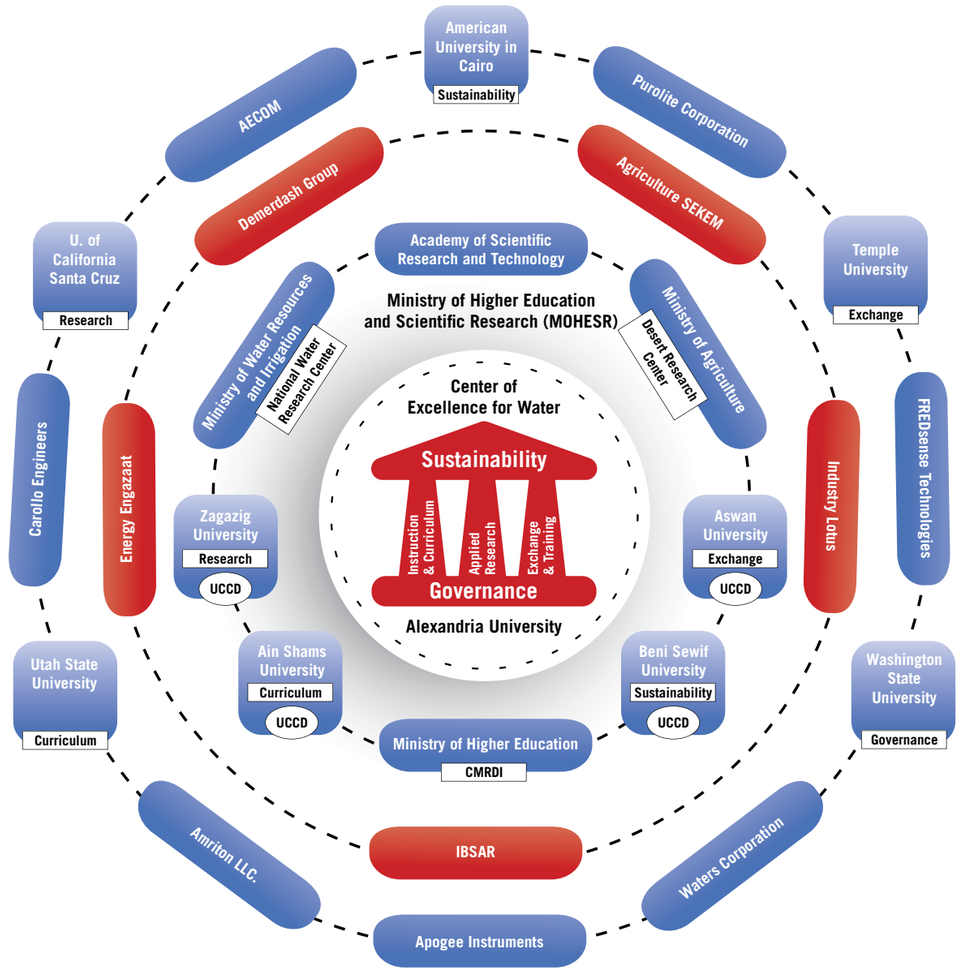


Figure 1 .The three circles of the project and its partners

The Center of Excellence is composed of five components: Governance, Curriculum, Research, Exchange, and Sustainability (Figure 2), each led by one of the five U.S. universities that formed the team selected by USAID The *Research* component of the project is chaired by the University of California, Santa Cruz, United States, and co-chaired by Zagazig University, Egypt.

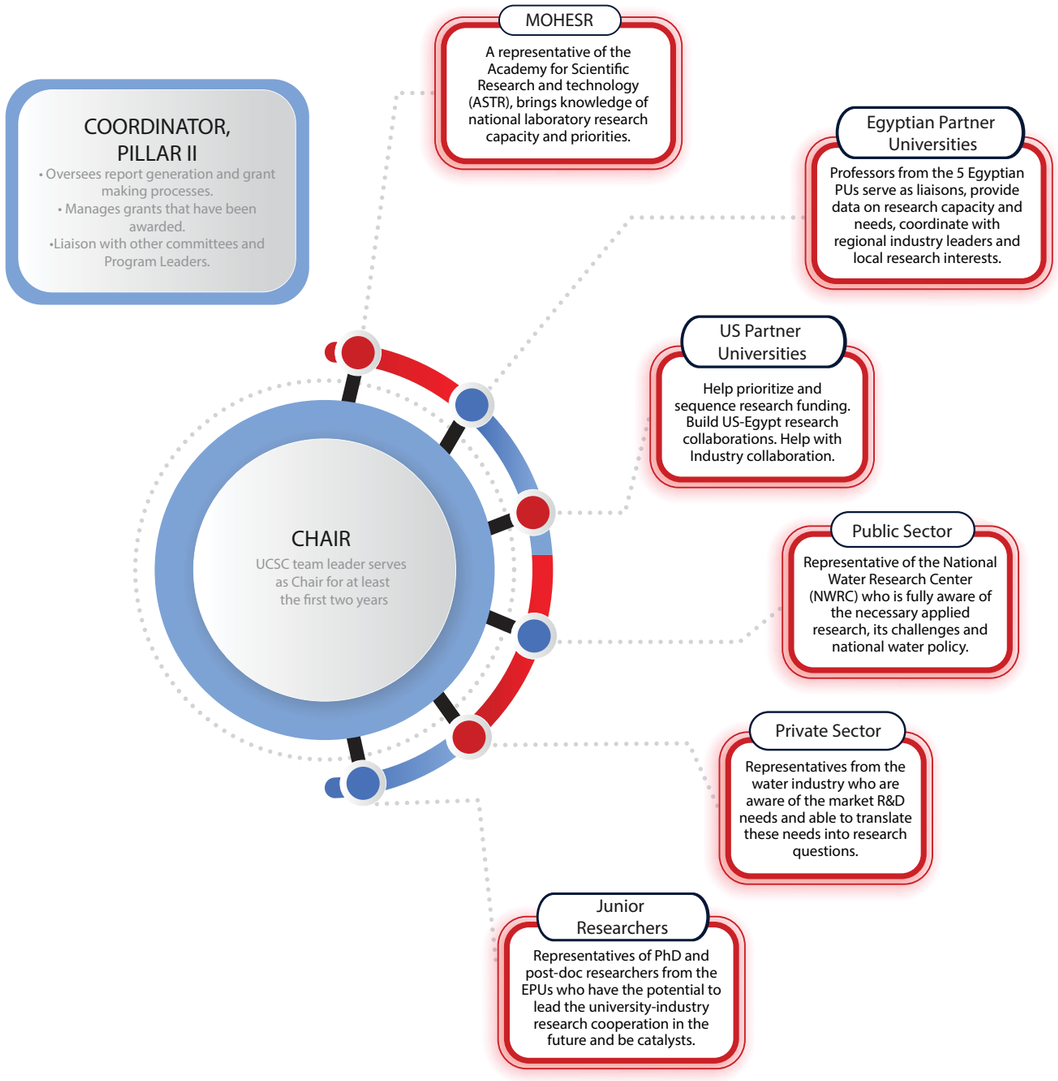


Figure 2 .The structure and composition of the RPC

The Research Pillar of the Center of Excellence is managed by the "Research and Policy Committee" (RPC), which is composed of representatives from several stakeholders from U.S. and Egyptian Universities, Research Centers, Public and the Private Sector (Figure 1). The RPC acts as an executive committee, which both manages and implements the goals of the research component of the project.

While one of the mandates of the Center of Excellence is to create a mechanism to fund applied research projects tackling real world problems in the water sector in cooperation with the public and private sectors, it has also a mandate to contribute to the overall Egyptian strategy for water research, by developing the "National Water Research Roadmap" (NWRR).

This document is the first iteration of the NWRR and will be followed by annual revisions to account for advancements in applied research and emerging needs within the Egyptian Water Research landscape.

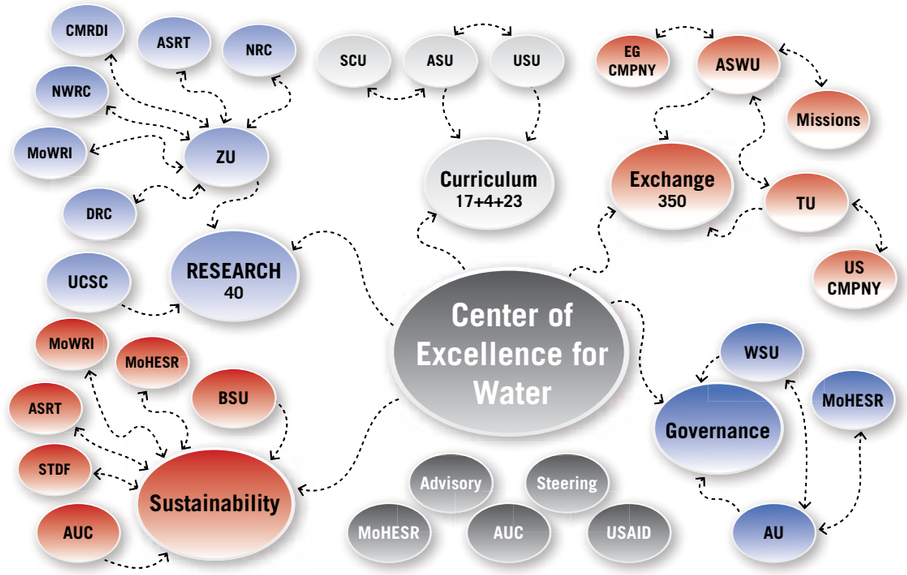


Figure 3 .The Mind Map of the project showing its components and stakeholders' relationships

2 Rationale behind the NWRR

In Egypt, the Ministry of Water Resources and Irrigation (MoWRI), the Ministry of Housing, Utilities and Urban Communities (MoHUUC), the Ministry of Higher Education and Scientific Research (MoHESR), the Ministry of Agriculture and Land Reclamation (MoALR), the Ministry of Environment (MoE), the Ministry of Trade and Industry (MoTI), the Ministry of Health and Population (MoHP), along with many other public entities and ministries develop and implement strategies related to the water sector. To complement and coordinate existing strategies, and move toward action plans of implementation, a NWRR will help prioritize the needed interventions of research, development, and innovation with respect to challenges facing Egypt in the water sector.

The NWRR is meant to address trends in Egyptian water supply and consumption and to identify future directions. The NWRR states needed research frameworks and the rationales behind them. The importance of having a research roadmap can be summarized in the following points:

- The NWRR will help identify Egypt's most urgent research needs. Identifying and prioritizing essential research topics will direct scarce resources toward the most needed research topics to assist in identifying responses to the challenges facing Egyptian society.
- The NWRR will define objectives for addressing interconnected research topics, highlight immediate significance of addressing important water research questions, and contribute to a framework of research funding accountability for academia, the public, and the private sectors.
- The NWRR will engage and enable the water-related private sector to help identify research needs and adopt and spread innovations emerging from research programs. The private sector will also participate in research development and execution, and direct and co-sponsor research, which will contribute direct value to society by advancing applied research and innovation.
- By linking actual societal needs with needed research, the NWRR can increase funding for higher education and scientific research institutions.

3 The Development of the NWRR

Egypt's *Vision 2030* stresses the commitment of the Egyptian government to create an innovative and knowledge-based society to support economic growth and secure human welfare.

Egyptian Partner Universities (EPUs) and Research Institutions (RIs) have the potential to support the public and private sectors in achieving these goals by providing solutions to existing challenges, developing a well-trained workforce, and encouraging innovation.

The Development of the NWRR is a continuous iterative process. The current version of the NWRR is the first version, and it is expected that it will be updated in an iterative manner annually, to allow for the inclusion/ exclusion of further challenges and reprioritizing challenges and modes of interventions taking into account the current state of research, development, and innovation in Egypt, in the U.S., and around the globe.

The current version of the NWRR sets the benchmark for the development of the roadmap and is intended to set the basis for further development that is expected to be done annually throughout the lifetime of the project establishing the Center of Excellence (until 2024), when it is handed over to the Center of Excellence-Water at Alexandria University.

The Methodology adopted by the Center of Excellence to develop the NWRR consists of the following steps:

- Designating a Center of Excellence-Water Research Team consisting of the Chair of the Research and Policy Committee, the Chief Science Officer, the Chief Technology Officer, the Chief of Party (Similar to Principal Investigator), and graduate students.
- Identifying real-world water challenges in Egypt.
- Identifying water research topics in Egypt based on literature review and primary research in the form of surveys and interviews with Egyptian water scholars on their opinions of the most important research topics.
- Analyzing water strategies adopted by different Ministries in Egypt in an attempt to understand the opportunities and approaches taken in dealing with the water challenges in Egypt.
- Identifying human and infrastructure constraints facing the EPUs and RIs in carrying out applied research that tackles these water challenges.
- Prioritizing research needs in light of the identified challenges and the role of research in addressing them.
- Validating the first version of the NWRR through consultation with high-level Egyptian and U.S. experts (from academia and the public and private sectors).

As mentioned before, further iteration to the NWRR is expected to be carried out annually throughout the lifetime of the project of the Center of Excellence. Therefore, it is expected that in subsequent years the following procedure will be followed:

- Assessing applied research projects carried out and solutions adopted throughout the year.
- Updating if necessary, the current list of water challenges for Egypt.
- Assessing changes in human and infrastructure constraints.
- Assessing any immediate needs for reprioritization of the research topics.
- Developing a new iterative version of the NWRR.
- Validating the iterative version of the NWRR through consultation with high-level Egyptian and U.S. experts (from academia and the public and private sectors).

The below flowchart depicts the methodology that was adopted in researching and writing the NWRR:

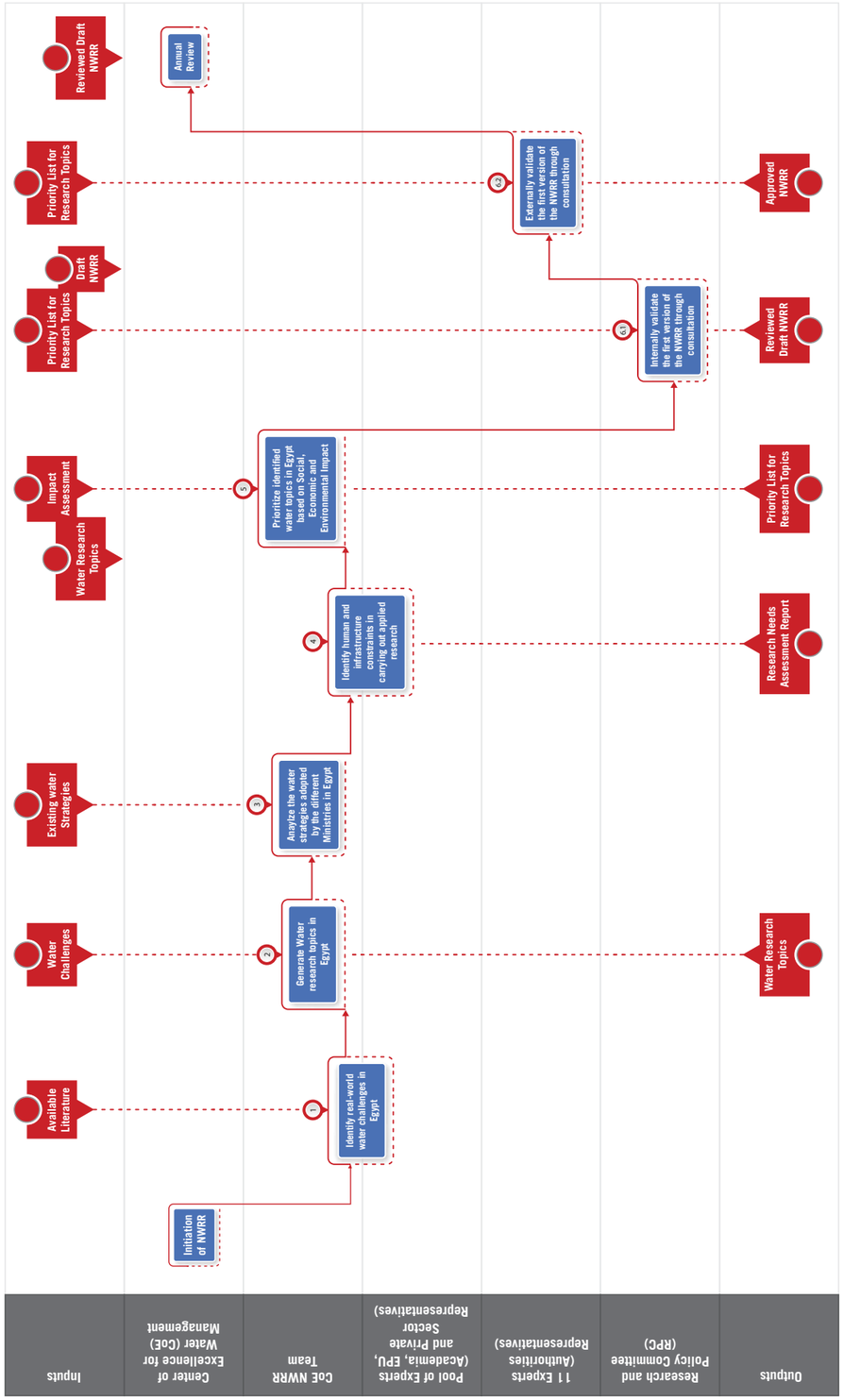


Figure 4 Adopted methodology for the Development of the overall NWRR

3.1 Water Challenges Facing Egypt

The Research Team of the Center of Excellence conducted an extensive literature review to identify water research challenges in Egypt, and also drew upon the expertise of the Research Team.

In parallel to the literature review, a Research Needs Assessment Campaign was carried out in Egypt, where online questionnaires and face-to-face meetings were conducted to help in identifying pressing research needs and challenges.

3.1.1 Literature review to identify water challenges

For the literature review, the Research Team of the Center of Excellence conducted in-depth desk review of available and scholarly literature on the topic existing for the last 20 years (cf. Annex I). Over 40 books and articles from local and global water experts were reviewed to infer sound scientific opinions about the recent and most pressing water challenges within Egypt and beyond. Among the prominent findings from Egyptian authors is the following short list of the freshwater challenges in Egypt [1].

- The increase in water demands due to rapid increase in population.
- The increase in demand in the upstream Nile countries and their construction of new dams.
- Expected climate change impacts on the Nile river flows.
- Aridity and low rainfall.
- Environmental impacts of drainage water reuse in contamination of freshwater resources.
- The high costs of seawater desalination and wastewater treatment.

In a different publication, Allam & Allam [2] argued that challenges related to institutional organization are among the many water-related challenges in Egypt. The types of issues within institutional organization include minimal cooperation between the MoWRI and other ministries in water management matters, inefficient communication and information transfer, as well as overly centralized decision making within the MoWRI.

Annex I give a detailed discussion of the literature review of identified water challenges for Egypt. The Research Team of the Center of Excellence believes that the following eight water challenges are to be considered, as they also encompass all other identified challenges by different authors and authorities:

- Water Scarcity
- Climate Change
- Transboundary Water and Water Security
- Water Quality
- Sanitation Coverage
- Aquaculture Sustainability
- Water Management for Irrigated Agriculture
- Water Economics

For example, connections between population growth and water demand motivate a number of challenges identified by the Research Team, including water scarcity, water economics, and others. The rest of the topics track nearly directly into the Research Team's list. The institutional focus of the Allam & Allam work focus on improving oversight and communication among research sponsors, which is something the Roadmap as a document could address. The Research Team list also encompasses additional topics, such as aquaculture, management, and economics.

The flowchart below depicts the methodology that was adopted by the CoE's NWRR Team in the process of Identification of Water Challenges in Egypt:

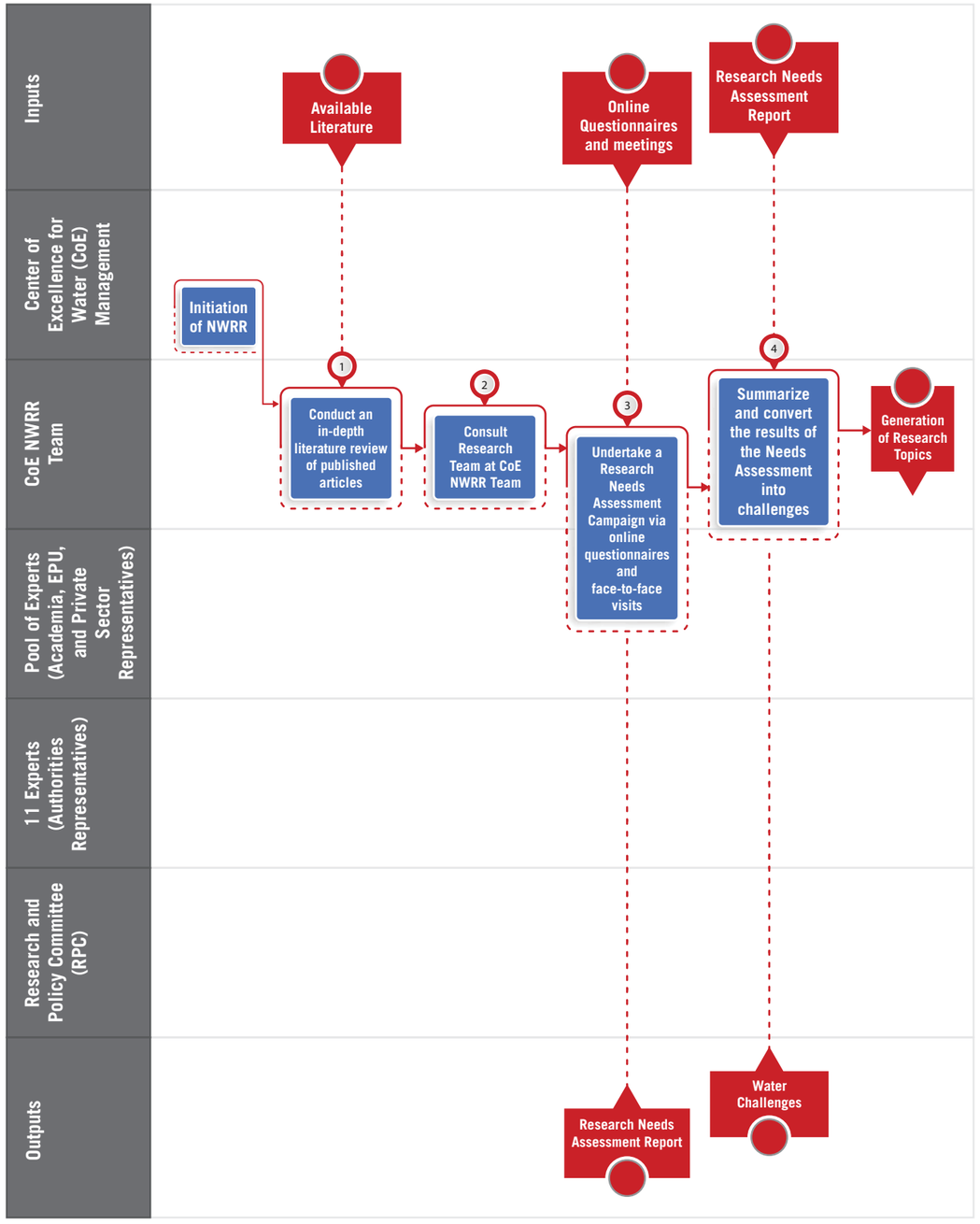


Figure 5 .Adopted Methodology for the identification of Water Challenges in Egypt

3.2 Process of Identifying Topics Requiring Water Research in Egypt

3.2.1 Research Needs Analysis Campaign

During the period of 9 – 26 September 2019, a Needs Assessment Campaign was carried out in Egypt, led by experts from Utah State University, with the participation of all the five U.S. partner universities in the Center of Excellence.

The Campaign had four objectives: to identify the needs and gaps in terms of Curriculum, to identify the needs and gaps in terms of teacher skills, to identify the needs and gaps in terms of infrastructure, and to identify the needs and gaps in terms of research topics and research capacity.

The Campaign was preceded by a data collection phase. A series of questionnaires (cf. Annex II) was sent to all stakeholders: universities, research centers, public and private entities, and others, and was complemented by the face-to-face visits to:

- The five public EPUs: Alexandria University, Ain Shams University, Aswan University, Beni Suef University, and Zagazig University.
- The Ministry of Water Resources and Irrigation.
- The Academy for Scientific Research and Technology.
- The National Water Research Center.
- The Desert Research Center.
- Private sector partners in the Center of Excellence (SEKEM and the Engazaat Group).

The results of the Needs Assessment Campaign are an assessment of the research topics in Egypt (Annex II provides the final report of the research needs assessment project). Figure 6 below summarizes research topics identified by respondents as follows:

1. Wastewater treatment
2. Desalination
3. Irrigation Water Management
4. Water Quality Assessment
5. Drinking Water Treatment
6. Ground Water Treatment & Exploration
7. Pollutant Fate & Transport
8. Fresh Flood Risk & Mitigation
9. Water Reuse
10. Renewable Energy
11. Water Use Efficiency
12. Water harvesting
13. Remote Sensing
14. Climate Change
15. Dam Failure
16. Water Economics
17. Riverbank Filtration
18. Ecosystem & Human Health Risk
19. Sustainability
20. Trans boundary Water Issues
21. Wadi Hydrology
22. Ground Water Modeling
23. Coastal Engineering
24. Remediation

The order in which those topics appear above is a ranking of the number of mentions by the respondents during the Needs Assessment, and Figure 6 provides a visual comparison of the number of mentions of each topic. These topics were aligned at a later stage, described in Section 3.5, with the results of the literature review. Based on the literature review, survey, examination of ministry priorities, and expert interviews, the research team has concluded the water challenges in Egypt in 8 water challenges priorities under which 15 research topics should be considered.

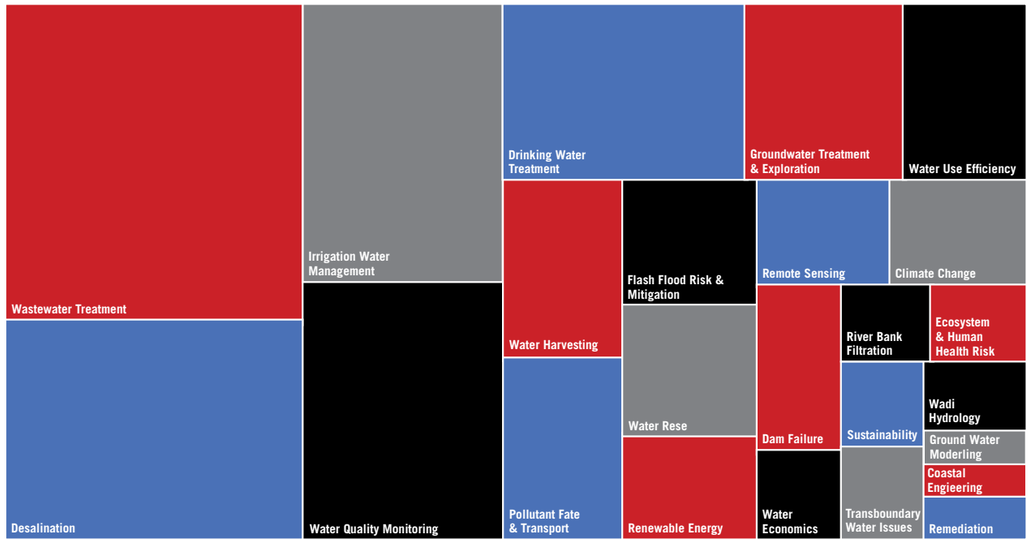


Figure 6 .Research Priorities Identified by Academic Respondents (note: a larger square means higher priority)

The below flowchart depicts the methodology that was adopted by the CoE's NWRR Team in the process of Identification of Research Topics:

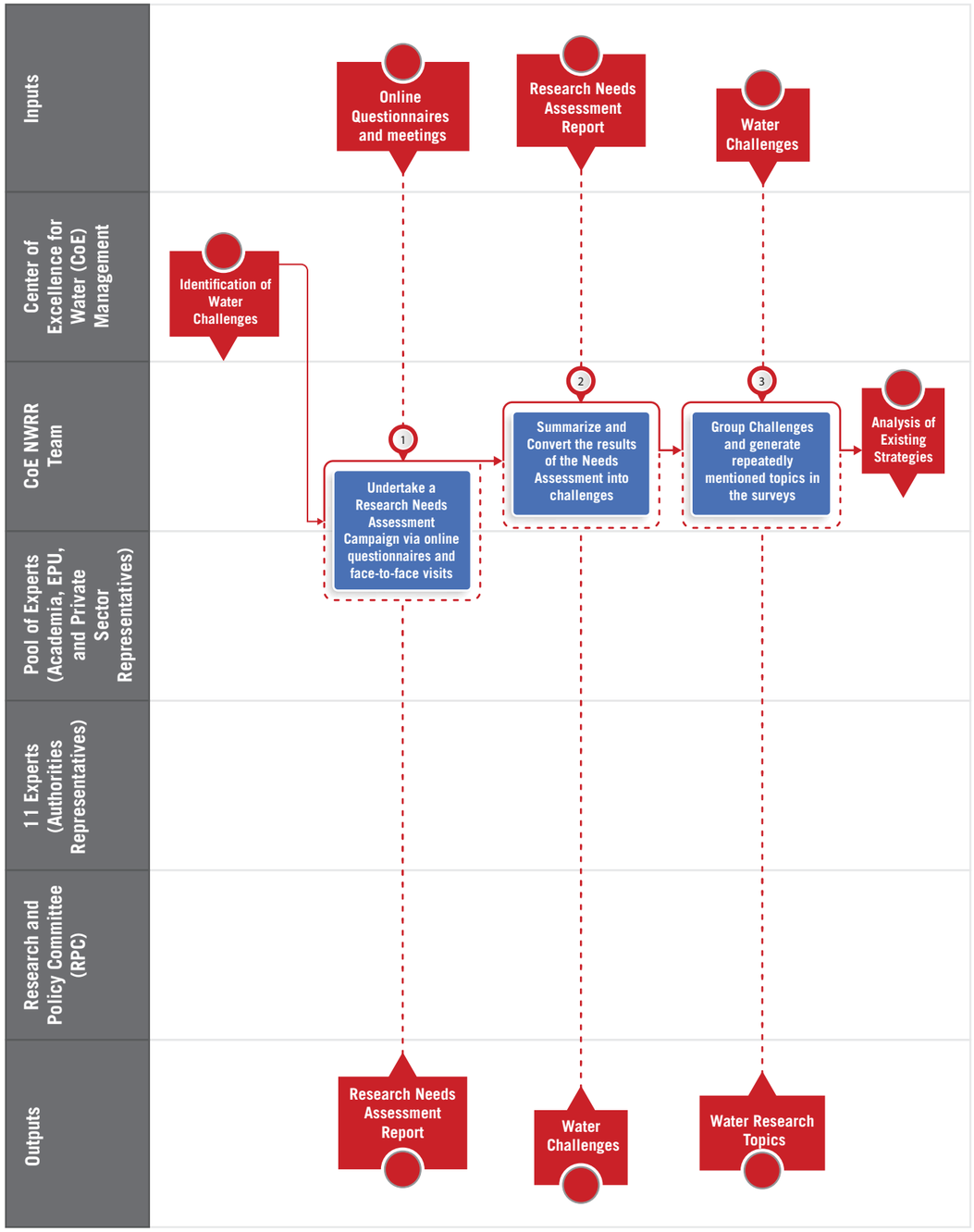


Figure 7. Shown the flowchart that depicts the methedology

3.3. Water Strategies Adopted by Different Ministries in Egypt

Several Egyptian Ministries are interested in water challenges as they relate to their core missions. In some cases they have developed strategies to address water problems This section provides an overview of the different available water strategies in Egypt and points out overlapping areas. Some of the ministries' water strategies are not made public yet and hence cannot be cited, while other ministries do not have documented water strategies to formally refer to and comment on. A draft "Water Strategies in Egypt" document discusses the published water strategies planned by ministries and various institutions in Egypt – such as those of the MoALR and the MoHESR, pointing out where they overlap. The methodology for this activity is reflected in Figure 8 below.

3.3.1 Ministry of Water Resources and Irrigation

MoWRI published its water plan NWRP2037 [3] wherein it addresses four main objectives: improving water quality, rationalizing water use, enhancing availability of freshwater resources, and improving the enabling environment for Integrated Water Resources Management (IWRM) in both planning and implementation.

3.3.2 Ministry of Agriculture and Land Reclamation

A MoALR draft strategy addresses a work scope that covers the following needs: sustainable use of natural agricultural resources, increasing water use efficiency in agriculture, adopting innovative water treatment technologies for treating wastewater from agriculture, and using new agriculture techniques like hydroponics technology. These topics are among the leading research needs in Egypt and are consistent with the Egypt's Vision 2030.

3.3.3 Ministry of Higher Education and Scientific Research

MoHESR monitors all research and development units established in Egypt's ministries and organizations that are concerned with water [4]. The ministry also studies exchange plans between Egypt and other countries with similar water challenges, establishes new departments in faculties and universities that study water use and management, and evaluates research undertaken for their quality and degree of applicability. MoHESR maintains a database of water research conducted and scientific papers published.

3.3.4 Ministry of Trade and Industry

MoTI oversees the industrial sector considered to be one of the main water users in Egypt, consuming 5 billion cubic meters of water annually. MoTI's water strategy includes limiting facilities that use surface water due to growing water scarcity.

3.3.5 Ministry of Environment

MoE seeks new innovative tools for assessing the environmental impact of all major water-using facilities in the nation. In addition, MoE seeks to study the impact of global warming on water quality and quantity.

In identifying and listing the water research priorities of the ministries, it appears there is an opportunity for ministries to consult and identify target areas for joint research projects as well as

for individual leadership. For example, the MoTI and MoE could work together to identify regions with the highest potential for benefits from industrial water treatment - at the least cost. Likewise, MoWRI and MoALR both have interests in agriculture IWRM and could identify together the aspects of greatest interest for investment.

The below flowchart depicts the methodology that was adopted by the CoE's NWRR Team in the process of Analyzing Existing Water Strategies:

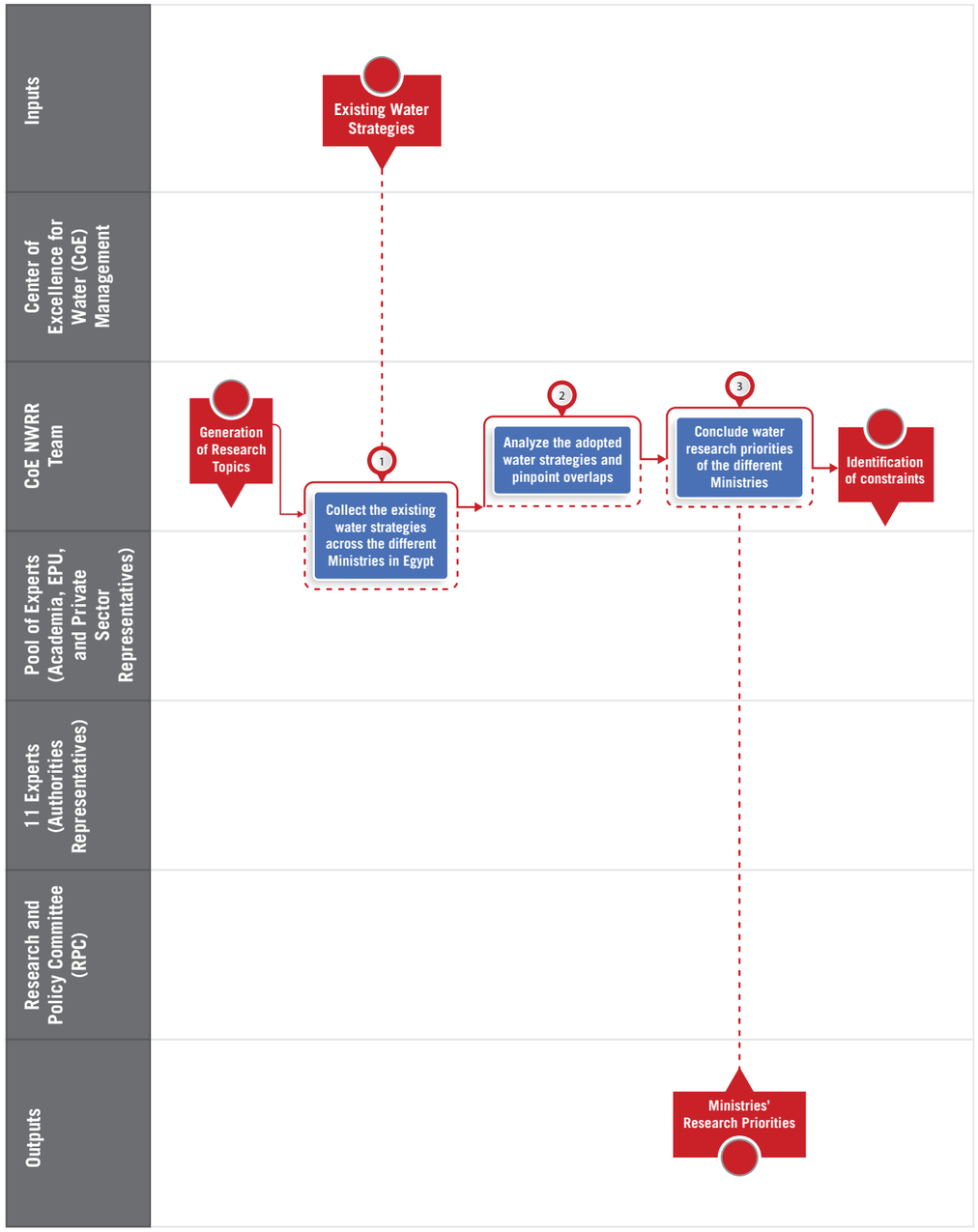


Figure 8. Adopted methodology for the Analysis of Existing Water Strategies

3.4 Human and Infrastructure Constraints

The water sector requires a wide range of research expertise. Research takes place in universities, research institutes, and in the private sector. Numerous university departments provide faculty who contribute to water research, including engineering, chemistry, biology, meteorology, public health, communications and sociology, hydrology, and geology. In engineering, numerous specialties contribute to water research, including water engineering majors, as well as civil, mechanical, environmental, and structural engineering. University laboratories and programs both undertake research and train the water workforce and research leaders of tomorrow.

3.4.1 Human Resources Constraints

A well-supported higher education system with funding that maintains faculty and researcher levels in water-related disciplines is a key input to the long-term success of Egypt's water sector. To realize this crucial "human capital" input, in addition to maintaining and growing the numbers of researchers in water-related fields, respective entities should promote exchange programs, knowledge transfer mechanisms, certification programs, and increased collaboration across sectors and disciplines in general. Degree and certificate programs that prepare students for water careers also generate the future leaders in water research. The same Needs Assessment project that generated the research needs reported here also identified needs for new degree programs and specialties (Annex II). At the graduate level, these include programs needed on Coastal Processes, Water Quality and Treatment, Laboratory and Field Measurements, Groundwater Hydrology, Water Chemistry and Microbiology, Digital Tools, Sustainable Water Management, and Non-Conventional Water Resources. Building these programs will have the added benefit of expanding Egyptian research capacity in all these fields.

3.4.2 Infrastructure Constraints

The infrastructure of research facilities must constantly be improved. Well-functioning, productive laboratories require a combination of leadership (professors and senior scientists), technical staff, students (if at a university), laboratory space, equipment, and budgets that include a consistent, regular operations element and a project-focused element. In the results of the 2020 Research Needs and Capacity Survey (Annex II), Egyptian faculty and laboratory directors identified water quality assessment equipment as their highest equipment need. The most important equipment needs included spectrometers and other testing systems. Typical areas mentioned as infrastructure constraints included the need for more applied research laboratories, the minor upgrade of existing labs and their respective equipment, the need to improve maintenance programs for existing equipment, and the lack of a successful and operational lab-use sharing model whereby different scientists could utilize the same research facility to maximize its use and benefit. This aspect could specifically be addressed through different collaboration schemes as presented below and in Section 3.5.3.1.

Another approach that helps with both personnel and infrastructure needs is to increase research collaboration across research institutes, universities, and the private sector. Agreements that allow researchers to share space and equipment can stretch existing resources and provide greater justification for additional investments that fill gaps. They can also stimulate new insights and approaches through additional communication among laboratories. This would include integrating needs identified by the private sector into public research programs and utilizing private sector

resources to carry out the research. Important constraints on cooperative sharing of laboratory facilities include a lack of scheduling mechanisms to avoid time conflicts, making others aware of laboratory resources and capabilities, and equitably allocating the fixed and variable costs of operating a laboratory among different groups and visitors.

The below flowchart depicts the methodology that was adopted by the CoE's NWRR Team in the process of Identification of Human and Infrastructure Constraints:

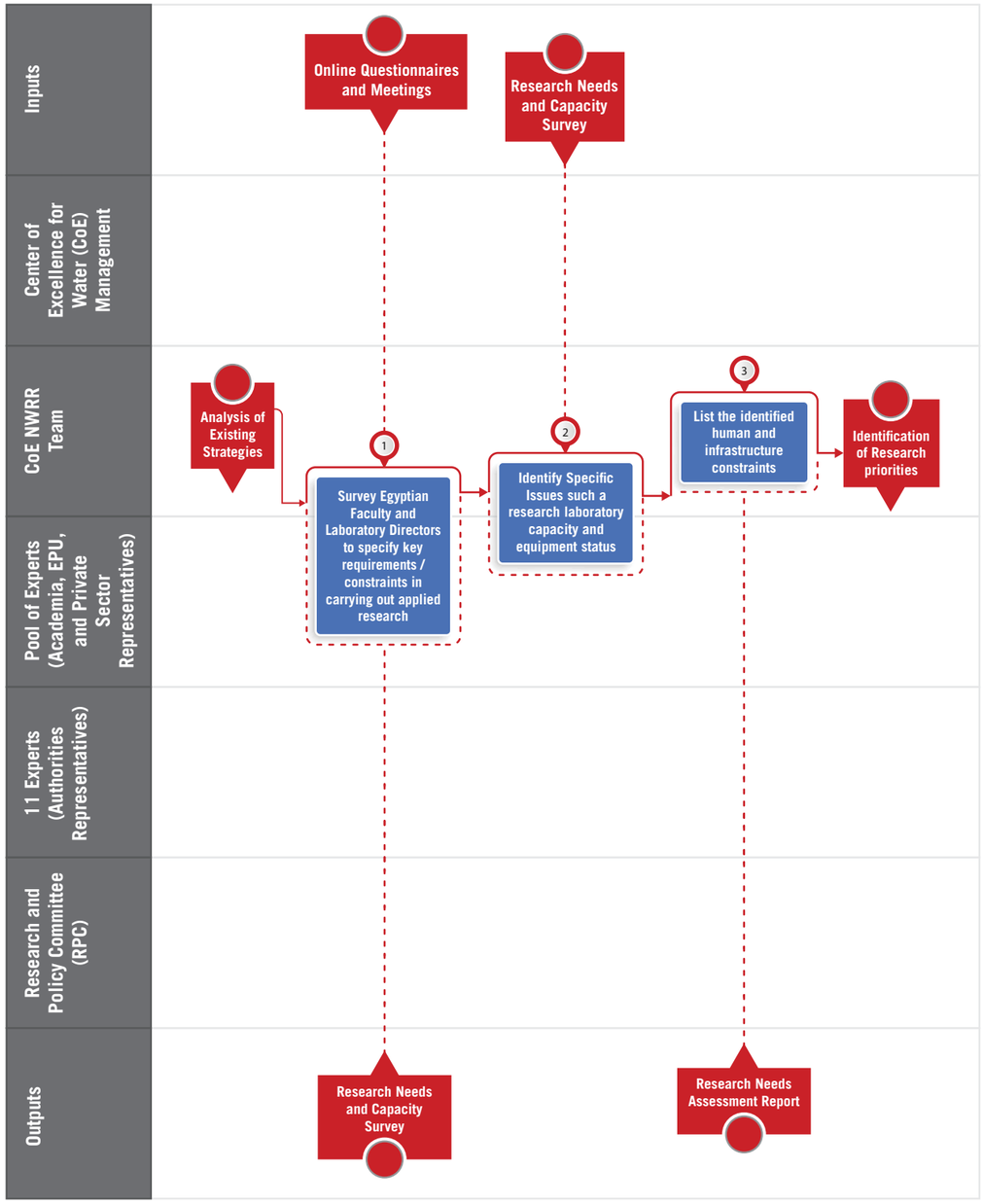


Figure 9 .Adopted methodology for the Identification of Human and Infrastructure Constraints

3.5 Identified Water Challenges in Egypt: Identifying Topics

In this section, identified water challenges in Egypt (Water Scarcity, Climate Change, Transboundary Water and Water Security, Sanitation Coverage, Aquaculture Sustainability, Water Quality, Water Management and Water Economics), as discussed in Annex I, are translated into research topics. Identified research topics are evaluated based on their potential social, economic, and environmental impacts that were predominantly captured from Egypt's Vision 2030 as well as the United Nation's Sustainable Development Goals (SDGs) [5] & [6]. The research topics are also evaluated in terms of their capacity to mutually enhance other goals and research programs. Prioritizing the topics did not take into consideration the cost of performing the research (e.g., purchase of laboratory equipment, salaries, number of scientists needed), only the potential impact of their outcomes and products on Egyptian society, economy, and environment, and their mutually supportive character. However, funding resources for water research is not infinite and decisions must be made to prioritize the final list and assign research areas to different funding sources.

The final priority list is based on impact, but it is expected that researchers and research funders may consider their own priorities for Egypt and what portfolio of investment is most likely to help.

The below flowchart depicts the methodology that was adopted by the CoE's NWRR Team in the process of Prioritization of Research Topics:

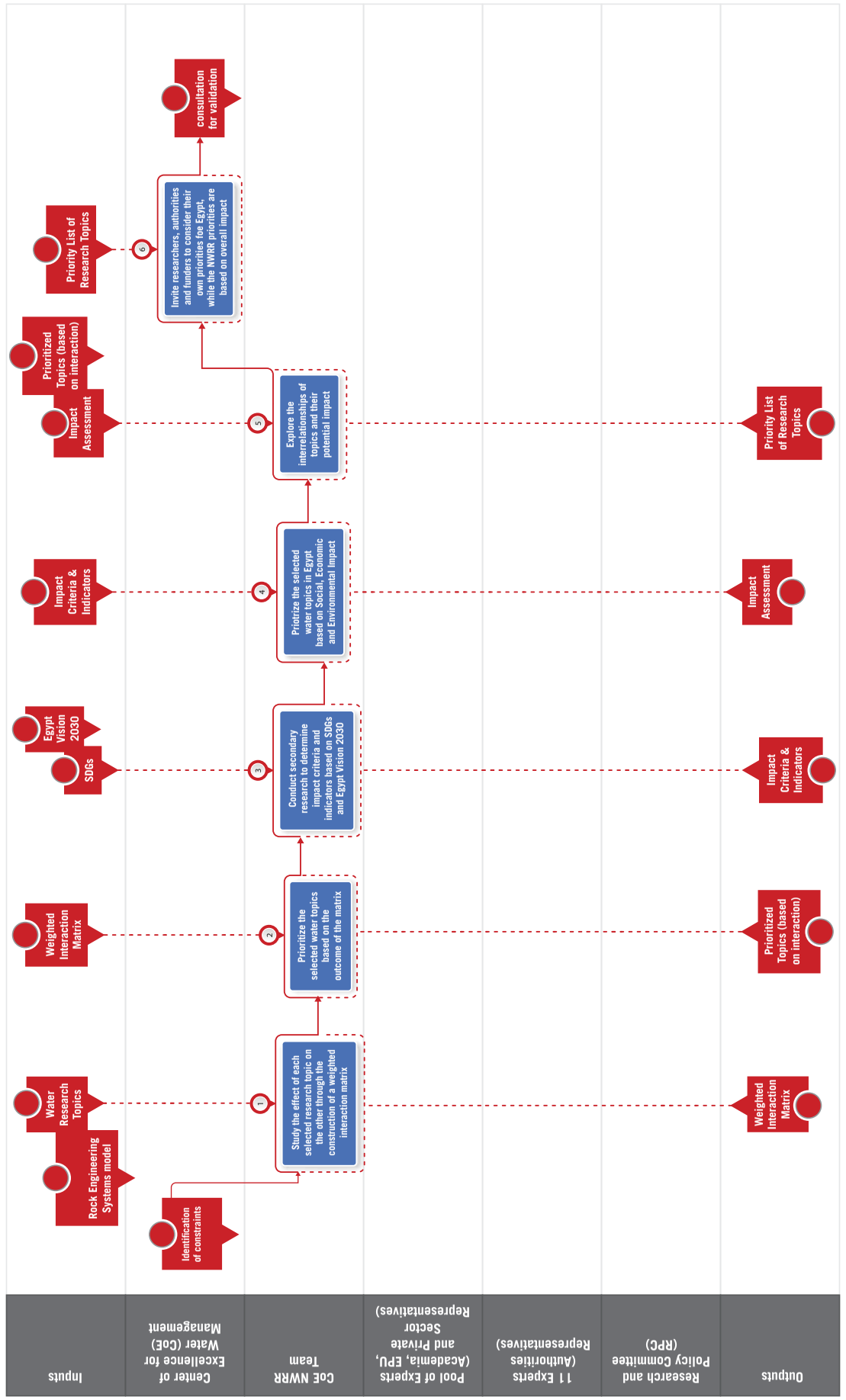


Figure 10. Adopted methodology for the Prioritization of Research Topics

Topic 1: Water Scarcity

Egypt is a water scarce country and approaching the absolute scarcity status (570 m^3 per capita per year). To overcome this challenge, research should be focusing on two main research areas.

I. Water Use Efficiency

Increasing water use efficiency is a key research area towards "producing more with less." This research area should include enhancing irrigation systems in Egypt and introducing new irrigated agriculture techniques. The focus of this research area will be mainly on agricultural, industrial, and domestic water use in Egypt. For example, in the Nile region, the focus should be on using modern irrigation techniques to enhance water use efficiency. In cities, the focus should be on identifying systemic inefficiencies such as pipe leaks and inefficient industrial or domestic devices.

II. Non-conventional water resources

Increasing available limited water resources will include expanding the use of desalination of sea and brackish water as well as treatment and reuse of agricultural and sewage wastewater. Research could include developing new technologies, (e.g., fog capturing, weather modification, and rainwater harvesting) if these technologies show promise of providing sufficient supplies, and adapting existing, even ancient ones, to Egyptian circumstances. Research into both technologies and the means of teaching end-users how to build, manage, and maintain systems could increase the use and cost-effectiveness of non-conventional sources.

Topic 2: Climate Change

Climate change in Egypt has different forms and impacts. However, the two main priority research area to be focused on are:

III. Vulnerability, adaptation, and mitigation of sea level rise

The assessment of vulnerability of Sea Level Rise (SLR) includes seawater intrusion into coastal aquifers, thereby increasing the salinity of groundwater formations used by agriculture and cities. For surface waters, SLR moves the saltwater-freshwater interface further inland, especially at high tide. SLR threatens agriculture activities further inland, with expected socio-economic losses over the Nile Delta. SLR also increases the risk of coastal infrastructure being inundated at high tide or during storm events. This is likely to cause not only economic losses but also risks to the livelihoods of millions of inhabitants of coastal zones, possibly endangering the stability of the entire society. In addition, there is a need to study local and regional adaptive capacity, different future mitigation scenarios, and the possible relocation of essential coastal infrastructure further inland.

IV. Temperature Increase and Hydrological Changes

Changes in area average temperature and precipitation over Egypt, as well as frequency of extreme events like heatwaves, have been assessed based upon over a dozen recent Global Circulation Models (GCMs). This makes it necessary to study the impact of increasing temperature and shifting seasons on water consumption of different sectors (agriculture, industry and domestic). In addition, more research on flash floods at different locations as well as heavy rainfall in the cities needs to be assessed in terms of overall impacts and vulnerability/ resilience of existing water infrastructure.

Topic 3: Transboundary Water

The waters of the Nile represent more than 97% of the total available freshwater resources for Egypt. Although the annual rainfall in the Nile Basin is about 1600 billion cubic meters (BCM), economic development in the Nile Basin countries is increasing pressure on the limited share allocated to Egypt (55.5 BCM). Moreover, uncoordinated projects on the upper Nile could reduce the flow of water to Egypt, which would dramatically affect the life of Egyptians and reduce the ability of the Aswan High Dam to serve as a resilient buffer for Egyptian water supply. This in turn could also negatively affect the amount of electricity generated from the Egyptian dam.

The Nubian Aquifer System (NAS) is a shared non-renewable aquifer shared within Chad, Egypt, Libya, and Sudan. Water availability is a problem and there are concerns about transboundary impacts of water use. Excessive depletion of this reservoir and spread of water-table drawdown across borders are causing shallow wells to dry and oases to disappear [7]. Water depletion and the continuous increase of cost of lifting water are of main concern which may eventually make groundwater production uneconomical in some locations. This reservoir should be dealt with in a more collaborative and sustainable approach especially given the risks and challenges facing Egypt with Nile River water.

Therefore, the focused research areas should be:

V. Transboundary River

Developing solutions that enable Egypt to collaborate with the Nile Basin countries in making use of the 1,660 BCM of annual rainfall in the Basin or even the 7,000 BCM of annual rain that falls specifically in the eleven Nile Basin countries. This could include research on rainfall harvesting, avoiding water losses, increasing the yield of the main river, increasing agricultural water use efficiency, improving floodwater capture and management, expanding smart resources management based on virtual water, integrating different renewable energy techniques to reduce relying on blue water for hydropower, and maintaining river water quality.

Aquifer management includes analyzing the current use and management of groundwater and developing more sustainable approaches and management strategies. This should include developing new scientific models to analyze and sustainably manage the NAS. Such tools should make use of geophysical prospecting, remote sensing, geoinformatics, isotope hydrology, environmental tracers, automatic data collection, modeling, and the coupling of models from different disciplines.

Topic 4: Sanitation

Over half of Egyptians live outside of cities. The lack of adequate sanitary facilities in rural areas is a major cause of pollution of both surface and groundwater sources, with associated health and economic productivity impacts. Research areas include:

VI. Safe treated wastewater reuse

Many villages transport sewage water using trucks that dispose of it in open agriculture drainage systems. The water of these drainage channels is considered to be “agriculture drainage” and available for reuse as such. Disposal of sewage water complicates the recycling process and affects the final quality of this important water supply. In the absence of full coverage of sewage system for these villages, there is a need for research that leads to innovative solutions for the challenge of rural wastewater disposal that enables safe water usage for agricultural purposes. Research is needed on methods and implementation for villages to provide adequate treatment of domestic sewage to make it safe to use for agricultural irrigation.

VII. Centralized/Decentralized Wastewater Treatment

“Decentralized” can mean as small as one house, or even a whole village that has a separate wastewater treatment system. Decentralized systems require local expertise, recognition of benefits, repair capacity, and financial capacity to remain in operation over time. There is a need for low-cost decentralized wastewater treatment to support the government in providing sewage treatment systems for Egyptian villages. It is necessary to assess the technologies currently used so that sewage treatment in rural areas can be developed appropriately. It is also necessary to develop and/or adopt wastewater treatment for the local circumstances in Egypt.

Topic 5: Aquaculture Sustainability

Aquaculture is the largest agriculture industry in Africa, contributing approximately 61.3% of the total fish production in Egypt, with about 1.14 million tons per year [7].

VIII. Increasing Fish Productivity per unit Water

In order to maximize the productivity of the water use, research activities should be carried out on the types of technologies and types of fish that together can enable reaching highly intensive fish production per unit of water. One example of the technologies that could be further developed for local manufacturing is “Recirculating Aquaculture System” (RAS).

IX. Integrated Aquaculture Systems

In order to maximize the productivity per unit of water in a sustainable manner, system integration could have great potential for producing more with less. For example, further research on optimizing the integrating of aquaculture with agricultural irrigation systems, that is, growing fish and using its water waste for irrigation systems, would include matching fish and crops, enhancing the quality of the produced fish and crops, and maximizing profitability. In addition, other areas for investigation could include connecting desalination and aquaculture in the form of aquaponics or other forms.

Topic 6: Water Quality

The main sources of water pollution in Egypt are the agricultural, domestic, and industrial sectors. The following are the two main research priorities for water quality.

X. Industrial Wastewater Management

Industrial wastewater is a serious challenge in terms of water quality management. Developing affordable and adoptable on-site treatment technologies and zero-liquid discharge systems for different industries in Egypt that dispose wastewater in the water systems would reduce the amount of water demanded by industry while improving the quality of effluent-receiving bodies. This, in turn, would reduce the cost of water treatment and reuse. Since industrial wastewater is often discharged into watercourses that ultimately are used for potable purposes, implementing systems for monitoring the wastewater via a source control program and monitoring the finished water to comply with drinking water standards for priority pollutants is important. Research is needed that identifies and focuses on monitoring removal of priority industrial pollutants.

XI. Remediation and Rehabilitation of Water Bodies

Developing affordable local technologies for enhancing the water quality of open water bodies such as lakes and irrigation channels should be pursued. Research can help lower the cost of remediation and rehabilitation of water bodies.

Topic 7: Water Management in Egypt

The agricultural sector consumes more than 80% of the available freshwater in Egypt. The two main priorities are:

XII. Farm Water Management/Irrigation Modernization

Research is needed for water efficiency and water productivity on the farm level in Egypt. This should include other dimensions for reaching sustainable farm water management beyond adoption of new technologies. Research is needed on irrigation scheduling, cropping pattern, water quality and minimizing the used synthetic fertilizers, and methods of irrigation (flood, spray, ridge and furrow, drip), among other topics.

XIII. Integrated Water Resources Management

The development of the overall IWRM in Egypt is essential in the era of climate change and upper Nile challenges. How will water be managed in a more efficient way? How will non-conventional water be integrated to the equation? What will be the priorities in the future? For example, how will trade-offs be made in a choice between water for agriculture or water for industry? Research on the methods and applications of integrated water resources management could help inform these questions.

Topic 8: Water Economics

Historically, agriculture water has been free of charge in Egypt. The cost of irrigation water is limited to the cost of pumping it from the open channels to the irrigated farm and possibly some taxes paid by farmers. There is no measurement of irrigation water in Egypt. To deal with the issues of water pricing and subsidies, there is a need to undertake research on:

XIV. Water Allocation

Water allocation addresses the planned distribution of water with an emphasis on end users and uses. It has urban and agricultural aspects. Urban aspects include how to improve systems of water capture, treatment, storage, and use within cities, such as stormwater capture and use. It also examines how water systems can be expanded as a city's population grows and the urban footprint expands under finite or slow-growing water supply. The agricultural perspective examines combinations of canals, pipelines, treatment systems, and other infrastructure that optimize a region's use of finite water supplies for agricultural and rural use. Uses of water for environmental purposes are also connected with agricultural and rural water allocation.

Water allocation is an integrative topic requiring expertise in data collection and data science, decentralized sensor and measurement systems, systems analysis including cost analysis, ecological systems, urban and regional planning, and civil and environmental engineering.

XV. Water Use Incentives

Studying the impact of water pricing on water use efficiency considering the social, economic, political, and environmental consequences. This should include all uses of water, including irrigation, industrial and domestic water.

3.5.1 Connections Between the Research Topics

All fifteen water research topics are important and deserve immediate attention. However, given the demands of high-quality applied research, which include trained personnel, laboratories, equipment, supplies, and multi-year budgets, the topics should be prioritized.

The Research Team of the Center of Excellence adopted a prioritization approach consisting of exploring the interrelationships of topics and their potential impact of the research on different aspects of Egyptian society, economy, and environment. It is not intended to be a definitive priority list of topics, as different funding sources have different priorities. Ministries, for example, have defined scopes and goals. The MoALR might prioritize research to expand irrigation water, while the MoHP might prioritize research on water treatment systems for human consumption. Private companies will focus on research related to market-based opportunities in their sectors. Universities have an interest in promoting research productivity building on their existing expertise and resources. Private foundations and international donors bring their own priorities to research programs, seeking to connect their priorities with Egyptian circumstances.

This approach to identifying connections focuses on the purpose or end-use of the research, not on the methods of doing the research. A focus on the methods of doing research might lead to a focus on, for example, hydroinformatics, which covers the application of data analysis techniques to water issues. Then, all topics that rely heavily on hydroinformatics would be sorted together. Other methods-based topics could include sensor-based research, modeling, and field studies. Instead, this approach focuses on purposes and goals that require additional research to achieve. An example is *vulnerability, adaptation, and mitigation of sea level rise*. As will be seen, this topic is closely aligned with *temperature increase and hydrological changes* in terms of its drivers and impacts, and potential for building a coherent portfolio of research topics

The relationship of each topic with the others is presented through the construction of an interaction matrix. The effect or relationship of interest is the extent to which an investment in research in one area provides synergistic support to research undertaken in another area. The support could take the form of solving related important problems or building needed research capacity.

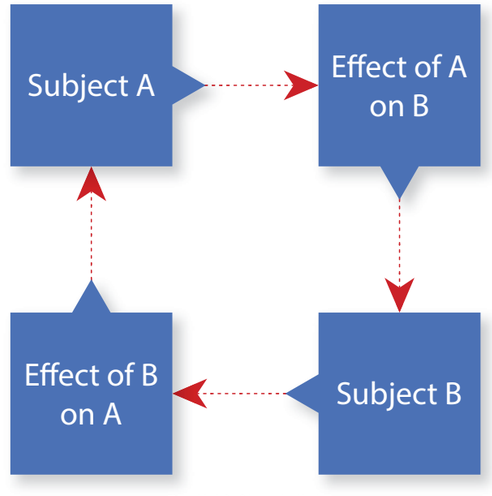


Figure 11 .A 2 x 2 Interaction Matrix

This method of presenting effect/relationship interactions via a matrix is an adaptation of the Rock Engineering Systems (RES) approach by J. Hudson [8] where it is used to study the combination, interaction or influence of one topic on another. For this, a square matrix is drawn where the main topics are placed in the leading diagonal positions and the interactions between the subjects are placed in the off-diagonal boxes. In the figure below a simple 2 × 2 matrix is shown, and it is clear that the concept could be generalized to an n × n matrix, where n is the number of subjects under consideration.

Research Topics	1. Water Use Efficiency	2. Non-conventional Water Resources	3. Vulnerability, Adaptation and Mitigation of Sea Level Rise	4. Temperature Increase and Hydrological Changes	5. Transboundary River	6. Safe Trated Wastewater reuse	7. Centralized/Decentralized Wastewater Treatment	8. Increasing Fish Productivity per Unit Water	9. Integrated Aquaculture Systems	10. Industrial Wastewater Management	11. Remediation and Restoration of Water Bodies	12. Farm Water Management	13. Integrated Water Resources Management	14. Water Allocation	15. Water Use Incentives
1. Water Use Efficiency		+		+	+	+++	+		+++		++	+++	+	+++	+++
2. Non-conventional Water Resources	+		+	+		+++	+++	+	++	+++	++	++	+++	+	+
3. Vulnerability, Adaptation and Mitigation of Sea Level Rise		+		+					+		++		+		
4. Temperature Increase and Hydrological Changes	+	+	+++		+++			+	+		++	+++	++	++	
5. Transboundary River	+			+++							+	+			
6. Safe Treated Wastewater reuse	+++	+++					+++		++	+	+	+	++	++	++
7. Centralized/Decentralized Wastewater Treatment	+	+++				+++			+	+++	+	+	+++		+
8. Increasing Fish Productivity per Unit Water		+		+					+++	++			++		
9. Integrated Aquaculture Systems	+++	++	+	+		++	+	+++			+	+++	++		
10. Industrial Wastewater Managment		+++				+	+++	++							+
11. Remediation and Restoration of Water Bodies	++	++	++	++	+	+	+		+			+	+		
12. Farm Water Management/Irrigation Modernization	+++	++		+++	+	+	+		+++		+			++	+
13. Integrated Water Resources Managment	+	+++	+	++		++	+++	++	++		+				
14. Water Allocation	+++	+		++		++						++			
15. Water Use Incentives	+++	+++				+++	+++			+++		+++			

Table 1 .Interaction Matrix for the identified Research Topics

Table 1. Interaction Matrix for the identified Research Topics below provides the squared interaction matrix of the relationships / effects between the identified research topics. Topics are arranged in the columns and rows, while the intersection of rows to columns shows effects of one topic to the other.

An absence of “+” means no effect/relationship between topics, a “+” means little to some effect/relationship, “++” means moderate effect/relationship, and “+++,” indicates strong effect/relationship among topics.

The next step in the interaction matrix is to sum up the amount of effect/relationship that each topic has. Table 2. Assessment of relative weight of each research topic with respect to each other below shows the topics, the number of effects for each topic and the relative “weight” of the effects, which is an indication of the relative importance for each topic.

Research Topics	Number of High Effect “+++”	Number of Medium Effect “++”	Number of Low Effect “+”	Ranked Sum of Effects (Relative Weight) in descending order
2. Non-conventional Water Resources	4	3	6	24
1. Water Use Efficiency	5	1	5	22
6. Safe Treated Wastewater reuse	3	4	3	20
4. Temperature Increase and Hydrological Changes	3	3	4	19
9. Integrated Aquaculture Systems	3	3	4	19
12. Farm Water Management/Irrigation Modernization	3	2	5	18
7. Centralized/Decentralized Wastewater Treatment	4	0	5	17
13. Integrated Water Resources Managment	2	4	3	17
11. Remediation and Restoration of Water Bodies	0	4	6	14
10. Industrial Wastewater Managment	2	1	2	10
14. Water Allocation	1	3	1	10
8. Increasing Fish Productivity per Unit Water	1	2	2	9
15. Water Use Incentives	1	1	4	9
3. Vulnerability, Adaptation and Mitigation of Sea Level Rise	1	1	3	8
5. Transboundary River	1	0	3	6

Table 2 .Assessment of relative weight of each research topic with respect to each other

Table 2 indicates that research on non-conventional water resources, and on water use efficiency, have the highest likelihood to increase the impact of water research broadly in Egypt. At the bottom of the table, research on transboundary river and aquifer management, while extremely important in its own right, is not shown to have strong impacts supporting other research areas.

3.5.2 Assessment of the Impact of Identified Research Topics on Egypt’s Social, Economic and Environmental Conditions

Based on sustainable development categories (Social, Economic and Environmental), and taking into consideration areas of overlap between Egypt’s Vision 2030 and the UN’s SDGs, we were able to identify 8 subcategories for Social Impact, 4 subcategories for Economic Impact, and 8 subcategories for Environmental Impact. Following the same approach, in Table 3. Interaction Matrix for the impact for each research topic on Egypt’s Social, Economic and Environmental conditions we illustrate an interaction matrix using a non-squared matrix to assess the impact of the 15 research topics on the three categories of impact. Here, the number of plusses indicates the extent to which the topic addressed by the research directly would improve that specific aspect of Egyptian society. As with Table 1, the scoring was undertaken by the Research Team based on their research findings.

	Impact	1. Water Use Efficiency	2. Non-conventional Water Resources	3. Vulnerability, Adaptation and Mitigation of Sea Level Rise	4. Temperature Increase and Hydrological Changes	5. Transboundary River	6. Safe Trated Wastewater reuse	7. Centralized/Decentralized Wastewater Treatment	8. Increasing Fish Productivity per Unit Water	9. Integrated Aquaculture Systems	10. Industrial Wastewater Management	11. Remediation and Restoration of Water Bodies	12. Farm Water Management	13. Integrated Water Resources Management	14. Water Allocation	15. Water Use Incentives
Social Impact Category	Reduces adverse impact on agriculture due to irrigation water shortage	+++	+++	+++		+++	++	+	+	+		++	+++	+++	+++	++
	Improves food production output	++	+			+++	++	++	+++	+++	+++	+	+++	++	+	
	Improves rural public health		+				+++	+++		+	+++	+		+		
	Improves urban public health		+++	+	+		+	++			+++	++		+		
	Increases community resilience to natural disasters	+	+	+++	++	++	+					+		++		
	Increases use of safe drinking water		+				+	+++				++		++		+
	Increases use of sanitation systems		+				+	+++				++		++		+
	Increases participation of local communities		+		+		+	+++				+	+	++		+
Economic Impact Category	Generates new agricultual employment	+	+	+	+		+	+	+	+			+	+	+	
	Generates new industrial employment							+		+	+					
	Increases economic output	+++	++				+	+	+	+			++			
	Improves energy system operations, including hydropower	+			++									+		+
Environmental	Protects endangered species			+	+++		+					+		+		
	Protects sites of important cultural heritage			++	++									+		
	Improves growndwater and surface water quality	++	++	++		+	+++	+++			+++	+++	+	++		
	Improves soil quality	+					++	+		+	+	+	+			
	Reduce CO^2 emissions											+	+	+		+
	Enhances adoption of renewable and alternative energy sources		+			+	+			+			+	+		+
	Improves air quality						+									
	Improves biodiversity		+		++							++	+	+		

Table 3 .Interaction Matrix for impact for each research topic on Egypt's Social, Economic and Environmental conditions

In order to quantitatively assess the global impact on Egypt's Social, Economic and Environmental conditions, we needed to add the number of effects on each condition to each other. Since the number of subcategories is not equal (8 for Social, 4 for Economic and 8 for Environmental), and in order not to give a false mathematical assessment for the significance of the impacts, we had to multiply the number of effects on Egypt' Economy by 2. Hence, we arrive at an equal weight for the three categories of impact.

Table 4. Assessment of the relative weight of each research topic with respect to Egypt's Social, Economic and Environmental conditions illustrates the final scoring for each research topic with respect to its corresponding impact category and relative to each other.

Research Topics	Social Impact (number of "+")	Economic Impact (number of "+" multiplied by 2)	Environment Impact (number of "+")	Relative weight (sum of impacts) in descending order
7. Decentralized Wastewater Treatment	17	6	4	27
13. Integrated Water Resources Managment	15	4	6	25
6. Safe Wastewater Use in Agriculture	12	4	7	23
2. Non-conventional Water Resources	12	6	3	21
1. Water Use Efficiency	7	8	3	18
11. Remediation and Rehabilitation of Water Bodies	12	0	5	17
12. Farm Water Management	7	6	4	17
4. Temperature Increase and Hydrological Changes	4	6	5	15
10. Industrial Wastewater Managment	9	2	4	15
3. Vulnerability, Adaptation and Mitigation of Sea Level Rise	7	2	5	14
9. Integrated Aquaculture Systems	5	5	2	12
5. Transboundary River and Aquifer Management	8	0	2	10
15. Water Use Incentives	5	2	2	9
8. Increasing Fish Productivity per Unit Water	4	2	0	6
14. Irrigation Water Measurement	4	2	0	6

Table 4 .Assessment of the relative weight of each research topic with respect to Egypt's Social, Economic and Environmental conditions

3.5.3 Discussion on Identified research topics and their relative weight (prioritization)

It is clear from the tables above that the relative weight of a research topic, which is an indicator of its priority, changes from one situation to another. When research topics are compared using an interaction matrix to account for their effect on each other, they reveal a certain order of priority (relative weight), while if their interaction-matrix ranking is compared to their Social, Economic and Environmental impacts, they reveal a different order. Recall that what is being compared is the potential benefit of the investment in research to achieve the stated goals, not the goals themselves

This is what has been mentioned in the introduction of Section 3.5.1 above. The relative weight/ priority of research is highly dependent on of the context of research funding, including the goals and priorities of the funder. The goals of the MoWRI are different than those of the MoALR, as are those of other funding agencies and programs.

In our case, we have adopted the interaction matrix to identify the relative weight for each research topic with respect to each other and with respect to Egypt's social, economic, and environmental impact. This methodology can be utilized to help any ministry or funding program identify priority research topics

3.5.3.1 Models of Collaboration and Public-Private Partnerships

Research collaboration is done for academic and research advancement purposes, or sectoral support purposes. Depending on the intended outcome of the research, the optimum collaboration approach is determined. In all cases a form of organizational learning and knowledge transfer is achieved through such collaboration efforts and hence, should be promoted and encouraged more. A common benefit to collaboration schemes lies in the fact that they tackle sustainability, make an impact, and create a mutually beneficial context for all partners. Nevertheless, fostering collaboration in the form of formal agreements ensures that outcomes are delivered, as well as, evaluated.

In the NWRR context, and due to limited funding and other recurrent constraints – such as human or infrastructure as referred to earlier in the document, collaboration agreements such as Memoranda of Understanding (MoUs) and Public-Private-Partnerships (PPPs) (with their various arrangements) could be a vehicle for research advancement. These agreements typically offer a framework for accountability & governance, sustainability, and evaluation that regulate the relationship between the participating parties. For instance, MoUs between the different EPUs or an EPU with a specific public entity, or PPPs between the EPUs and the private sector could help overcome funding continuity issues through ensuring a more sustainable funding mechanism and impactful outcome through continuing the research program to completion.

While the collaboration or funding could be in the form of research grants, other important but often overlooked aspects worth investing in are related to the human resource and the research infrastructure development. Investing in Exchange Programs (academic or professional) could significantly develop the skillset of researchers and create “relevance” which the private sector usually expresses its lacking due to the disconnect between theoretical areas of study and practical challenges that are faced. Similarly, investing in adding, upgrading, or maintaining existing lab equipment is equally crucial as an enabling tool for researchers to advance in their findings and contributions. Accordingly, research collaboration agreements encompass the vested interest of both the public and the private sector in resolving the existing water challenges in Egypt.

The below flowchart depicts the methodology that was adopted by the CoE’s NWRR Team in the process of consultation on the NWRR:

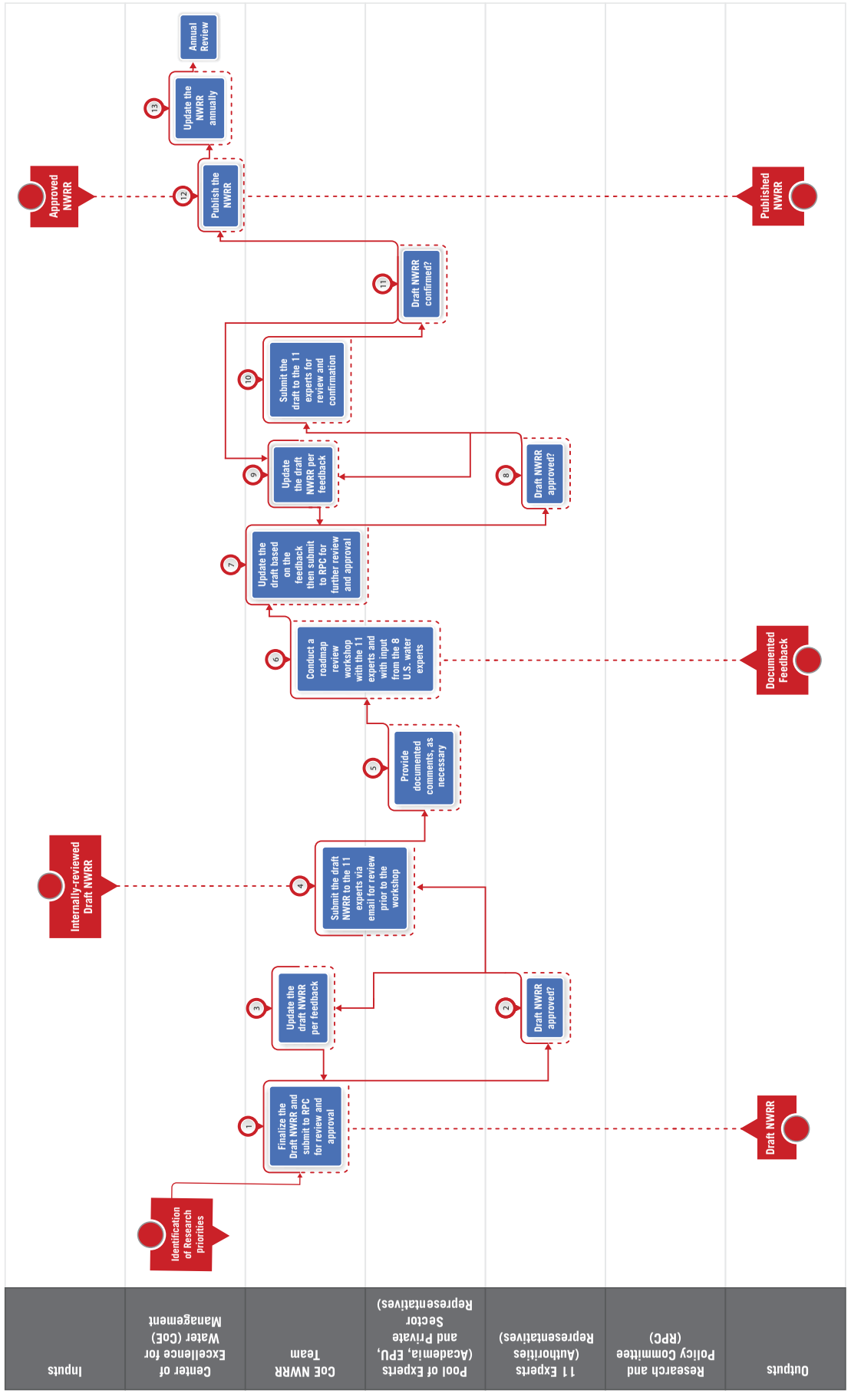


Figure 12 .Adopted Methodology for the Consultation Process on the draft NWRR

3.5.4 Validation through Consultation on the NWRR

The current document is the product of the Research Team of the Center of Excellence, in addition to several rounds of consultations among the Center of Excellence's partners in Egypt and the U.S.

Nevertheless, an important step for the validation of the NWRR, is the formal consultation with the main stakeholders in academia and the public and private sectors. A broad range of perspectives strengthens the internal logic, conclusions, and applicability of the Roadmap and helps build enduring partnerships. It is through this dialogue that we can help implement a more effective NWRR, with annual updates through an iterative format.

For the formal consultation with stakeholders, an identified list of 11 representatives of experts from both ministries and academia have been selected by the Center of Excellence to participate in the first round of formal consultation on the NWRR - 4 experts from the MoWRI, the MoALR, the MoHESR, the MoHUUC respectively: and 7 experts in Water Sciences and Engineering from academia.

3.5.5 National Consultation Workshop (3-6 March 2021)

During the period of 3-6 March 2021, a national consultation workshop was held at Ain Sokhna, Egypt with the participation of the following experts from Egypt (In Alphabetical Order):

- Prof. Ahmed Balah, Assistant Professor, Irrigation and Hydraulics Department, Ain Shams University
- Prof. Ahmed Gaber, Professor of Remote Sensing, Head of the Technical Office of the Egyptian Cabinet
- Prof. Gihan Gewaifel, Alexandria University
- Eng. Mohamed AlMetwally ElSayed, Teaching Assistant – Department of Water Engineering and Hydraulics, Ain Shams University
- Prof. Mohamed Nasr Eldin Allam, Professor of Water resources at Cairo University and former Minister of Water Resources and Irrigation
- Prof. Mohamed Noureldin, Professor of Water Resources and Environmental Management, Ain Shams University
- Dr. Osama Elzaher, Undersecretary of the Ministry of Water Resources and Irrigation for Minister's Office.
- Dr. Ramy Hamdy Abdelhady, Assistant Professor, Zagazig University
- Prof. Sayed Ismail, Deputy Minister of Housing and Land Reclamation.

The meeting was partially attended (two zoom sessions of 2 hours each), by a panel of experts from US institutions, identified by Prof. Brent Haddad, the chair of the Research and Policy Committee for the Center of Excellence for Water (in Alphabetical order):

- Prof. Brent Haddad, Professor of Environmental Engineering, University of California at Santa Cruz, Chair of the Research and Policy Committee of the Center of Excellence for Water
- Prof. David Emmanuel Rheinheimer, Research Professor at Technologico de Monterrey, Mexico, and Member of American Society of Civil Engineers.
- Dr. James Crook, Ph., PE, International Authority on Water Reclamation and reuse.
- Dr. Jean Debroux, Chief of Technology Officer, Kennedy/Jenks Consultants.
- Prof. Sunny Jiang, Chair, Environmental Engineering, University of California, Irvine.

In addition to the research team of the Center of Excellence for Water (in Alphabetical Order):

- Mr. Akram Ali, Senior Researcher
- Prof. Essam Shaban, Technical Advisor
- Dr. Hamdy Maamoun, Senior Researcher
- Prof. Hany Sewilam, Lead Scientist
- Ms. Rawnaa Yassine, Research Coordinator
- Prof. Yasser Elshayeb, Chief of Party

3.5.6 Proceeding and Prioritization

During the three days meeting, thorough and detailed discussions about the draft NWRR document took place. Discussions about the identification of challenges and their inherited topics of research were presented.

A workshop on prioritization was held on day 2 of the workshop to illustrate how each entity (Ministry / authority / research fund, etc.) may use the prioritization tool to address their respective strategies and priorities.

The following table shows the relative weight of each of the research topics for the experts

Research Topics	COE-W	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Expert8
1. Water Use Efficiency	22	24	32	24	26	25	33	25	28
2. Non-conventional Water Resources	24	14	2	21	23	20	20	17	26
3. Vulnerability, Adaptation and Mitigation	8	9	4	11	24	16	10	4	16
4. Temperature Increase and Hydrological Changes	19	14	12	19	24	14	18	15	18
5. Transboundary River	6	5	6	17	27	17	14	7	18
6. Safe Treated Wastewater reuse	20	20	15	23	25	23	21	21	30
7. Centralized/Decentralized Wastewater Treatment	17	10	17	20	13	12	19	16	20
8. Increasing Fish Productivity per Unit Water	9	4	17	14	17	13	12	11	17
9. Integrated Aquaculture Systems	19	8	15	19	20	24	12	13	21
10. Industrial Wastewater Managment	10	4	10	18	15	14	17	17	19
11. Remediation and Restoration of Water Bodies	14	7	22	29	18	24	15	23	27
12. Farm Water Management Irrigation Modernization	18	13	17	23	27	23	16	20	14
13. Integrated Water Resources Managment	17	13	23	33	31	27	28	18	33
14. Water Allocation	10	9	18	14	27	19	15	19	29
15. Water Use Incentives	9	13	22	25	29	21	8	16	26

Table 5. Relative weight (priority) for each topic as identified by the experts

It is expected that since experts are having diverse background and are representing different institutions, that the relative weight for each topic would be different from one expert to the other. Nevertheless, all of them have agreed about the list of challenges and topics.

In an attempt to identify the high priority research topics that would be used by the Center of Excellence for Water in its subsequent calls for applied research, the team of the Center of Excellence for Water have done a quantitative data analysis on the feedback from the experts as follows:

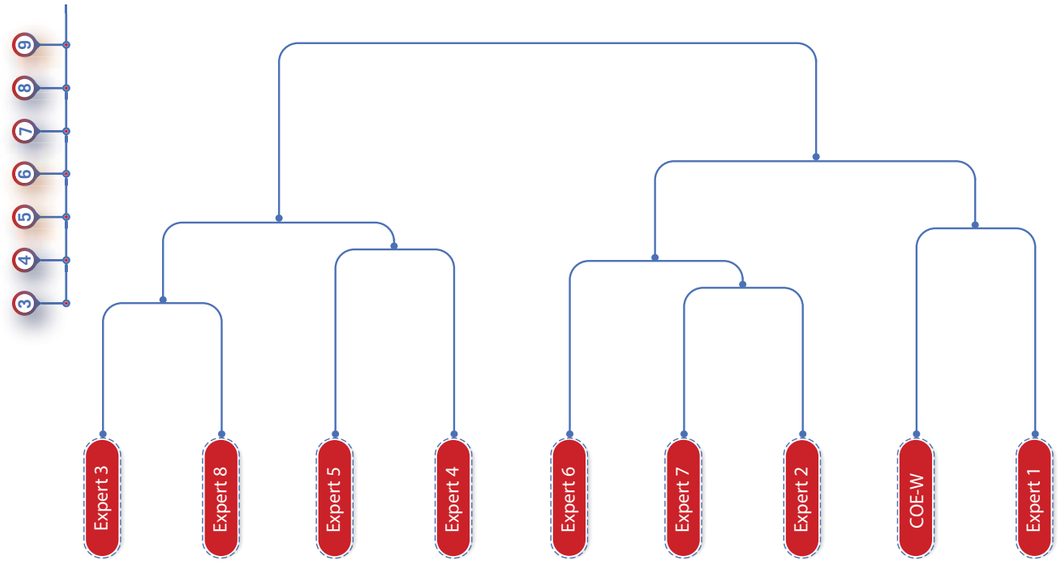
1. Identification of Outliers
   Despite the fact that the number of experts is limited, an outlier analysis of the scores showed that some experts, for some topics, had outlier values (high or low). Those extreme values are highlighted in bold and red in the table below

Research Topics	COE-W	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Expert8
1. Water Use Efficiency	22	24	32	24	26	25	33	25	28
2. Non-conventional Water Resources	24	14	**2**	21	23	20	20	17	26
3. Vulnerability, Adaptation and Mitigation	8	9	4	11	24	16	10	4	16
4. Temperature Increase and Hydrological Changes	19	14	12	19	24	14	18	15	18
5. Transboundary River	6	5	6	17	27	17	14	7	18
6. Safe Treated Wastewater reuse	20	20	**15**	23	25	23	21	21	**30**
7. Centralized/Decentralized Wastewater Treatment	17	10	17	20	13	12	19	16	20
8. Increasing Fish Productivity per Unit Water	9	4	17	14	17	13	12	11	17
9. Integrated Aquaculture Systems	19	8	15	19	20	24	12	13	21
10. Industrial Wastewater Managment	10	4	10	18	15	14	17	17	19
11. Remediation and Restoration of Water Bodies	14	7	22	29	18	24	15	23	27
12. Farm Water Management Irrigation Modernization	18	13	17	23	27	23	16	20	14
13. Integrated Water Resources Managment	17	13	23	33	31	27	28	18	33
14. Water Allocation	10	9	18	14	**27**	19	15	19	**29**
15. Water Use Incentives	9	13	22	25	29	21	8	16	26

Table 6. Identification of outlier values for prioritization (NOTE: Some numbers are of different color)

2. Identification of similarities of prioritization
   Another attempt to look into the collected prioritization information consisted of studying the similarities of prioritization among the various experts, in search for a consensus on the priority list of topics.

The following graph shows a dendrogram of similarity among the experts after using outlier values, which shows that mainly the panel of experts (and the team of the Center fo Excellence for Water) are divided into two similar groups: Group 1 containing experts 3, 4, 5, and 8 Group 2 containing experts 1, 2, 6, 7, and the team of the Center of Excellence for Water.



3.6 Conclusions and list of priorities for the Center of Excellence for Water

Although no consensus on prioritization of topics was reached (which is expected), the team of the Center of Excellence for Water -after the above-mentioned quantitative analysis of prioritization data- have opted for the following list of 5 topics to be considered in its subsequent calls for Applied Research Proposals:

1. **Water use Efficiency**
2. **Integrated Water resources Management**
3. **Safe Treated Wastewater reuse**
4. **Non-conventional Water Resources**
5. **Remediation and restoration of water bodies**

It is of course understood that such a list of topics may undergo changes / amendments in the next iterations of the NWRR.

4 How to use the NWRR document

4.1 Objectives of the first version of the NWRR

This first version of the NWRR is intended to serve the following purposes:

1. Stimulate a broader focus on and discussion of Egyptian water research priorities. The participation of dozens of Egypt's leading water scholars and government and private sector leaders, as well as U.S. experts, have already contributed to this dialogue. Ideally it will contribute to discussions at future forums, including Egyptian Water Week.

2. Help research funding agencies, ministries, universities, the private sector, foundations, and aid agencies to focus on the most important water challenges Egypt is facing, and what research is needed to address them. For example, the Center of Excellence-Water will utilize the NWRR to help determine its future calls for water research proposals. The NWRR may help with coordination between goals and funded programs among different agencies, as well as the oversight and record-keeping role of the MoHESR.
3. Set a scientific approach to prioritizing research topics through the usage of interaction matrices and relative weights for impacts and effect. Such scientific approach could be adopted by various stakeholders (ministries, funding agencies, private sector), and/ or adapted by the same entities to identify/adjust their own priority list of research topics.

4.2 NWRR Review and Update Mechanism

The NWRR is intended to be updated annually. The sources of information that will influence annual versions include the results of research undertaken in the previous year, new information on the challenges Egypt faces, expert feedback on the NWRR itself, research that adds insights into the analysis made in this first version and changing national priorities. Such needs or justifications for update – apart from the regular annual review – shall be communicated through a *"NWRR Change Request"* as attached in Annex IV. The NWRR will exist in a setting of active ongoing research, graduate degree programs developing the next generation of water leaders, communication between scholars and the public and private sectors about research findings and priorities, and ongoing investment in solving Egypt's water challenges. The extent and fruitfulness of these interactions will help determine the advances of future versions of the NWRR especially when handed over to the Center of Excellence for Water at Alexandria University. Furthermore, subsequent versions of the NWRR will venture into specifics related to the impact of each research topic on sustainable development aspects, required human, financial, infrastructure and technological resources, and timeframes for carrying out research projects.

5 List of Contributors to the NWRR document

5.1 From the Center of Excellence for Water (in Alphabetical Order)

- Mr. Akram Ali, Senior Research Officer, The American University in Cairo
- Prof. Brent Haddad, The University of California at Santa Cruz, and Chair of the RPC
- Ms. Dania Sherif, Consultant, The American University in Cairo
- Prof. Essam Mohamed, Technical Advisor, The American University in Cairo, and Member of the RPC
- Prof. Hani Sewilam, Lead Technical Scientist, The American University in Cairo, and Member of the RPC
- Ms. Rawnaa Yassin, Senior Research Coordinator, The American University in Cairo
- Ms. Stephanie Webb, PhD Candidate, The University of California at Santa Cruz
- Prof. Yasser Elshayeb, Chief of Party, The American University in Cairo, and Member of the RPC.

5.2 Members from the Research and Policy Committee (in Alphabetical Order)

- Prof. Abdelazim Negm, Zagazig University, and Co-Chair of the RPC
- Prof. Ahmed Farghali, Vice Dean for Post-graduate Studies & Research at Beni Suef University, and Member of the RPC

- Prof. Aly Elbahrawy, Ain Shams University, and Member of the RPC
- Prof. Asmaa Hammouda, Beni Suef University, and Member of the RPC
- Mr. Ayman Elsaady, Technical Office Director at the National Water Research Center, and Member of the RPC
- Prof. Emad Hegazy, CEO at STDF of Ministry of Higher Education and Scientific Research, and Member of the RPC
- Prof. Gihan Gewaifel, Research Pillar Coordinator, Alexandria University, and Member of the RPC
- Prof. Hany Madkour, Aswan University, Member of the RPC
- Prof. Hesham Gaber, Vice President for Alexandria Committee, Alexandria University, and Member of the RPC
- Mr. Hossam Shawky, Director at Desert Research Center, and Member of the RPC
- Prof. Jonathan Yoder, Washington State University, and Member of the RPC
- Prof. Khaled Gemail, Zagazig University, and Member of the RPC
- Prof. Rominder Suri, Director of Water and Environmental Technology Center at Temple University, and Member of the RPC
- Prof. Ryan Dupont, Utah State University, and Member of the RPC

5.3 Experts for consultation / review on the NWRR draft (in Alphabetical Order)

- Prof. Abdelaziz Konsowa, President of Alexandria University, Professor of Water Treatment, former Governor of Alexandria, Alexandria University
- Prof. Ahmed Balah, Assistant Professor, Irrigation and Hydraulics Department, Ain Shams University
- Prof. Ahmed Gaber, Professor of Remote Sensing, Head of the Technical Office of the Egyptian Cabinet
- Prof. Hesham Gaber, Professor of Agriculture, Vice President of Alexandria University for Students Affairs, Alexandria University
- Dr. Eman Soliman, Head of Planning Sector, Ministry of Water Resources and Irrigation
- Prof. Hossam Shawki, Professor of Water Desalination, Desert Research Center, Director of the Egyptian Alliance for Water Desalination
- Prof. Mahmoud Sakr, President of the Academy for Scientific Research and Technology, Ministry of Higher Education and Scientific Research
- Eng. Mohamed AlMetwally ElSayed, Teaching Assistant – Department of Water Engineering and Hydraulics, Ain Shams University
- Prof. Mohamed Nasr Eldin Allam, Professor of Water resources at Cairo University and former Minister of Water Resources and Irrigation
- Prof. Mohamed Noureldin, Professor of Water Resources and Environmental Management, Ain Shams University
- Dr. Osama Elzaher, Undersecretary of the Ministry of Water Resources and Irrigation for Minister's Office.
- Dr. Ramy Hamdy Abdelhady, Assistant Professor, Zagazig University
- Prof. Saad Nassar, Advisor to the Minister of Agriculture, Former Director of the Agriculture Sector Education at the Supreme Council of Ministries, and Former Governor of Fayoum
- Prof. Sayed Ismail, Deputy Minister of Housing and Land Reclamation.

6 References

[1] Radwan. G. Abd Ellah, “Water resources in Egypt and their challenges, Lake Nasser case study” The Egyptian Journal of Aquatic Research, no. 46, pp. 1–12, 2020, doi: 10.1016/j.ejar.2020.03.001.

[2] M. N. Allam and G. I. Allam, “Water resources in Egypt: Future challenges and opportunities,” Water International, vol. 32, no. 2, pp. 205–218, 2007, doi: 10.1080/02508060708692201.

[3] Preparation of the National Water Resources Plan for Egypt 2017-2037 (NWRP 2017-2037) https://eeas.europa.eu/delegations/egypt/43747/preparation-national-water-resources-plan-egypt-2017-2037-nwrp-2017-2037-%E2%82%AC2-million-grant_en

[4] National strategy for Science and Technology 2030.” Accessed: Feb. 04, 2021. [Online]. Available: http://www.crci.sci.eg/wp

[5] “Egypt 2030 - SDS Egypt 2030.” http://sdsegypt2030.com/?lang=en (accessed Sep. 24, 2019).

[6] Sustainable Development Goals, UNDP, http://UNDP.org

[7] C. I. Voss, S. M. Soliman, and P. K. Aggarwal, “Effective groundwater modeling of the data-poor Nubian Aquifer System (Chad, Egypt, Libya, Sudan) - use of parsimony and 81Kr-based groundwater ages (Invited),” AGU Fall Meeting Abstracts, vol. 13, pp. H13I-1487, Dec. 2013.

[8] J. A. Hudson, Rock engineering systems: theory and practice. Chichester: Ellis Horwood, 1992.

7 Annex I: Literature Review of Water Challenges in Egypt

Topic 1: Water Scarcity

Egypt is a water scarce country and approaching absolute scarcity status. Uncertain water supplies, desert covering most land, a dry climate, and scarce rainfall are the characteristics of Egypt. In addition to the allocated 55.5 BCM/year Nile River water share, 2.7 BCM/year of non-renewable deep groundwater can be utilized over a 100-year period [1]. The share of freshwater per capita per year is currently 573 m^3 which is far below the water poverty line.

Egypt's population is projected to increase from 111 million in 2020 to 137 million by 2030, and 154 million by 2037 [2]. This will contribute to a rapid decrease in per capita water availability per year if the amount of available water resources remains constant. The growing population will also lead to a substantial increase in agricultural production required to match the expected food demand and avoid dependence on imported basic food supply to the extent possible. There will be further increased water demand associated with improved standards of living and industrial modernization, adding further stress on national limited water resources and water supply and treatment infrastructure [2].

Since agriculture consumes 85% of available water resources in Egypt, along with the poor irrigation management practice in on-farm low efficiency irrigation systems, water scarcity will not be the only challenge but also food security. Surface irrigation efficiency in Egypt is as low as 60%, enduring losses in applied irrigation water into the drainage canals [2]. To face this challenge, the Egyptian government has imposed modern irrigation systems on farmers in newly reclaimed lands, but some farmers have switched back to surface irrigation, after removing the drippers and sprinklers, due to the high maintenance cost of the modern system [2].

The use of non-conventional water resources became essential in Egypt due to the fact that water demand is larger than the conventional supply [1]. A better use of every drop of water is needed under these water scarcity conditions in Egypt. Wastewater outflow and drainage represent 27% of the yearly water budget [2] [3].

The Agriculture Research Center in Egypt proposes further research and development activities to combat water scarcity by updating data on natural resources (land, water, and climate) using GIS and satellite data, and studying the agro-climate system including the potential of rain-fed agriculture and rangelands. Also, Allam & Allam [2] suggest the decentralization of water management down to the district level accompanied by extensive capacity building programs for farmers.

That being said, David Molden [4] argues that "There is no scarcity of water, only scarcity of management" as he has learned from the renowned water leader, Prof. Asit Biswas. Even in wet environments water scarcity can be experienced while well managed water resources in harsh environments can thrive. While expansion in irrigated agriculture may drive basin-level scarcity, cities, agriculture, and industry need a holistic basin management approach. Egypt has a physically water-scarce environment, but the very important question to ask is, 'how far can the Nile be stretched to provide for the increasing demand for water, food and expanding cities?' When hydrologic limits are reached, people need to develop the skills to live with the available resources and adapt to the natural variability of the water cycle. At the end, more trained water managers are needed not just to deal with the complexity of hydrology but also to understand the social aspect of the problem [4].

Topic 2: Climate Change

Egypt's Nile water is significantly affected by climate change, in terms of precipitation and temperature changes; of which there is an interrelated relationship between both. Studies indicate that a 4°C increase in temperature paired with a 20% rainfall decrease could reduce the River Nile flow by 98%. Similarly, a 2°C increase with the same 20 % reduction in rainfall would result in an 88% decrease in Nile flows. Climate change also affects the timing of snowmelt and runoff into rivers, and inflows into reservoirs. Sea Level Rise (SLR) is another direct threat that climate change poses to Egypt, leading to further environmental hazards such as storm and coastal floods which causes coastal erosion, saltwater intrusion into coastal freshwater aquifers, land inundation, and soil salinity [5]. The World Bank stated that in the case of 1-meter Sea Level Rise, 6.1 million coastal inhabitants could lose their homes and 4500 km^2 of agricultural lands would be lost, resulting in a 6% loss of Egypt's Gross Domestic Product (GDP) [5] [6]. In addition, global warming raises the water demand of plants, due to increased evaporation, placing more pressure on already scarce water resources [6]. Climate change could also affect the aquatic environment, as SLR destabilizes the breeding grounds of fish and marine organisms disturbing their food chains. Egypt lacks a comprehensive legislative framework for climate change adaptation and mitigation strategies [6]

In a study by Gebre [7], five different Global Circulation Models (GCMs) provided in a different projected response to climate change over the Blue Nile Basin. The European Community Earth-System Model (EC-EARTH) and the Institute Pierre-Simon Laplace (IPSL) GCM projected an increase in runoff change whereas the Hadley Centre Global Environment Model Version 2 (HadGEM2-ES) projected a decrease in average runoff change for the different catchments of the Blue Nile basin International Centre for Integrated Mountain Development (ICIMOD). Nevertheless, the same study found that temperature and evapotranspiration will increase significantly in all five GCM models, which would have a significant impact on the overall water budget [7].

According to Siam & Eltahir [8], long-term flows of the Nile are approximately 80 km^3y^{-1} and projected to increase to 92 km^3y^{-1} by the end of this century. The advantage of this study over most other studies on climate change effects on the Nile River Basin is that it uses recent observations and climate models' simulations to support the hypothesis that both the long-term mean and interannual variability of the Nile River flow may increase due to climate change.

In another attempt to study the effect of climate change on water resources in the upper Blue Nile Basin of Ethiopia, Roth et al. [9] conclude that streamflow is projected to increase either mildly (+0.71%) or dramatically (+97%) and thus the baseline streamflow is expected to increase all year long. Climate change scenarios suggested that the precipitation will increase from 7% to 48% and that streamflow from the Blue Nile Basin could increase by 21% to 97%. However, the effect on the Blue Nile outflow remains uncertain. The main rainy season is expected to gradually decline in intensity with precipitation becoming more distributed throughout the year [9].

Another climate change impact on the water resources in Egypt involves **seawater intrusion** into the groundwater aquifers in the Nile Delta and upcoming of saline water in areas of excessive pumping [9]. Nofal et al. [10], studied the mechanism and process of seawater intrusion into the coastal aquifers of the Nile Delta. They concluded that shallow to medium depths (up to 400m) are affected by seawater intrusion whereas in the deeper layers, groundwater fluxes are flowing towards the sea [10]. The effect of climate change on groundwater salinization is directly related to recharge rates. If recharge rates decline due to a decrease in precipitation, groundwater salinity could increase, and vice versa.

Hoerling et al. [11], indicated that a 0.5 °C warming in sea surface temperature (SST) over the Indian Ocean is likely to enhance drying, and thus heat-wave occurrence, over the eastern Mediterranean. According to Lelivated [12], climate changes over the eastern Mediterranean and the Middle East would have significant impacts on the region, with profound changes to agricultural zones, especially in Egypt, where water resources are limited.

As an example of climate change mitigation measures, flood risk management is studied by Mahmoud & Gan [13] in two governorates in Egypt, Beheira and Alexandria. The study shows the importance of flood susceptibility maps in land use mapping and flood mitigation in municipalities, the importance of rescue operations during flood events. Despite a decrease in annual precipitation, unpredictable rain events of short duration increase the chances of flooding, along with poor drainage systems and rapid urbanization.

As for agricultural production, Smith [14] estimated a decrease in agricultural production by 8-47% and a reduction in agriculture related jobs up to 39% due to climate change by 2060. Also, the projected losses in agriculture are estimated between 40 to 234 billion Egyptian Pounds by the year 2060.

Topic 3: Transboundary Water and Water Security

The Nile water represents more than 97% of the total available freshwater resources for Egypt. Although the annual rainfall in the Nile basin is about 1600 BCM, economic development in the Nile Basin countries is increasing the pressure on the limited Nile water share allocated to Egypt (55.5 BCM). In 2011, Ethiopia began its construction on the Blue Nile, with a reservoir area of 1874 km^2 and volume of 74 BCM at full supply [15]. The construction of the dam is expected to reduce Egypt's share. The losses caused by the dam as well as its filling and long-term operation rules are of major concern. It is expected that Ethiopia will continue constructing dams, as will other Nile basin countries, which will further threaten Egyptian water security. The main concern comes from the fact that the Ethiopian Plateau provides 86% of the Nile flow; 59% by the Blue Nile, 14% from Sobat and 13% from Atbara; while the contribution of the equatorial lakes is limited to 14% flowing through the White Nile [16].

Egypt is a country that is affected by climate change, not just within its borders but outside too, within the whole Nile Basin [16]. Meanwhile, rising temperatures is causing an increase in the evaporation process in natural ecosystems leading to an increase in water demand [6] [16]. The share of Egypt in the Nile water has not changed since the 1950s, despite the increase in population and high rates of development, and the Renaissance Dam acts as a direct threat to Egypt's share [16].

Batisha [17] summarizes the benefits sustaining Nile flows to include soil conservation, improved ecosystem sustainability, and water quality conservation. Opportunities through cooperation would include increased productivity at the basin scale, availability of hydropower, increased agricultural production, and regional trade. He concludes that cooperation through a Nile Basin Initiative holds potential for a win-win situation among riparian countries.

Topic 4: Sanitation Coverage

The lack of adequate sanitary facilities in rural areas is a major cause of pollution of both surface and groundwater sources. Unsafe water and inadequate sanitation systems rank the third among the 20 leading risk factors for health problems in developing countries [18-21]. In 2017, the rural population in Egypt accounted for 57.6% of the total population, yet only 55.89% of the population have access to safe sanitary water connections.

In 2014, around 91% of the Egyptian population received water directly into their residence. This indicates that 7.3 million people do not have access to safe water, among which 5.8 million who live in rural areas. Around 12% of the rural population live in dwellings not connected to water systems, while in urban areas, 4% do not have water connections. In rural areas, on average, the share of population without access to adequate sanitation was around 15% in 2014, compared with around 1% among urban dwellers [18-21].

Poor hygiene as well as limited access to water and adequate sanitation help spread disease. Diarrhea is the second leading cause of death in Egypt among under-5 children. Dehydration and loss of large quantities of water and electrolytes cause most diarrhea-related deaths in children. The root cause of water pollution in rural areas is caused by the discharge of wastewater from human, animal and agriculture sources, with little or no prior treatment [18-21]. Rural households which lack a formal sewage network system rely on individual means of waste management such as septic tanks and informal sewage networks. Informal sewage networks discharge waste directly into canals, whereas the inefficient design of septic tanks leads to the overflow of sewage, and the leakage of untreated effluent, contaminating both soil and groundwater. As the infiltration water load increases, so does the groundwater table, leading to higher contaminant interactions between surface water and groundwater [18-21].

Although new sewage systems are being constructed in Egyptian cities and villages, the financial burden of such infrastructure development is increasing. The annual investment in water supply and sanitation increased from 5 billion Egyptian Pounds in 2004/2005 to 15.7 billion Egyptian Pounds in 2008/2009 and was expected to rise to up to 200 billion Egyptian Pounds between 2010 and 2020 [18]. According to the World Health Organization [19] Egypt has achieved 86% of the target of halving, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation [20] [21]. Nevertheless, El-Kowrany et al [22] indicated that the middle region of the Nile Delta lacks an adequate water sanitation system and that biological agents, especially water-related protozoal infections, hold a real risk to the populations.

Topic 5: Aquaculture Sustainability

Aquaculture is the largest agriculture industry in Africa [23], contributing approximately 61.3% of the total fish production in Egypt with about 1.14 million tons per year. It is expected to continue increasing due to the application of new technologies and enhanced farm management practices [23]. While aquaculture is a major industry, according to Law 124 of the year 1983, it is not allowed to utilize freshwater, and is mostly dependent on water from agriculture drainage channels and groundwater [23]. However, since partially treated and untreated wastewater is discharged into open water bodies that provide irrigation water to agriculture, some aquaculture practices result in the production of fish of exceptionally low quality.

El-Gayar [23] discussed the sustainability of the aquaculture industry in Egypt. Ecologically, for an aquaculture system to be sustainable, it has to result in a non-negative change in the stock of natural resources and environmental quality over time. Hence, fry supply, choice of production technology and aquaculture production location play important roles in sustainability. Water quality management and disease control are directly related to the choice of production technology. Although this has not become an issue in Egyptian aquaculture markets yet, intensive increases in production will lead to further deterioration of water quality and stress on the cultured organisms, which increases the susceptibility to disease. The necessity of raising

awareness and improving practices of water quality management among Egyptian practitioners will improve its sustainability.

Khalil and Hussein [24] experimented growing O. niloticus on treated wastewater and observed higher growth rates compared to fish grown on other water sources. Yet, there have been concerns related to higher microbial loads in gills and heavy metals in the lungs. Therefore, the establishment of a regular system for monitoring fish tissues being disease free and free from drug residues and toxic contaminants is essential for public health safety Shaalan et al. [25]. Also, Abdallah and Elmagd Morsy [26] have found residues of heavy metals, with lead having the highest concentration, in fish farmed in Lake Edku in northern Egypt. This research underlines the importance of expanding research on the role of water quality in aquaculture.

Topic 6: Water Quality

The main sources of water pollution in Egypt are the agricultural, domestic, and industrial sectors. Improperly managed agricultural practices and associated drainage networks lead to water-quality degradation, including increased salinity levels, eutrophication due to excessive amounts of nitrogen and phosphorus nutrients from fertilizers and bacteria from livestock feeds [16]. The over application of fertilizers at an average rate of 319 kg nutrients (N,P,K)/ha, due to frequent and intensive cropping patterns results in groundwater nitrate contamination of the water table and drainage water, with adverse impacts on drinking water quality, as well as fish and aquatic organisms [16].

Excessive reuse of **agricultural drainage** accumulates salts in agricultural lands that seeps into groundwater aquifers causing contamination with toxic pollutants and chemical elements In 2005, the MoWRI developed a National Water Resource Plan for the year 2017 that has identified two priority issues regarding water quality: health and safe reuse [18].

Despite all the facts mentioned, the report on the state of water in Egypt in 2012 found that the water quality is good on average in Lake Nasser, the Nile River and Damietta branch with a water quality index of 100% in 2012. The Rosetta branch showed a water quality index of 83.5% in the same year. The indicators considered in this study were dissolved oxygen, PH, electric conductivity, total dissolved solids, nitrogen concentration, phosphorus concentration, fecal coliform, biological and chemical oxygen demand (BOD & COD), chloride concentration and total hardness [19].

Only about 35% of the total **municipal wastewater** discharged is treated, resulting in the direct discharge of about 3.8 BCM/ year back into surface waters as polluted return flow [19].

Industrial wastewater is another challenge in terms of water quality management. Unsafe drinking water that is exposed to pesticides causing renal diseases for around 72% of patients have been identified by researchers in public health in El Minya. Around 102 industrial plants have been recorded by the Egyptian Environmental Affairs Agency (EEAA) to have been dumping their wastewater either directly into the Nile or through the municipal system in 2008. It is also worth noticing that 10-20% of the population in Egypt suffer from long-term illness or need medical care owing to kidney failure, cancer and/or Hepatitis C virus [19-21]. Similarly, industrial effluents contribute to about 1.3 BCM/year of water discharge into water systems [21].

As for **groundwater quality**, generally the groundwater in the Nile Delta is better in quality than that in the Nile Valley. Critical values of drinking water are usually not exceeded in the newly reclaimed areas in the fringes while on long-populated lands of the Delta area, high concentrations of iron and manganese are found. Seawater intrusion acts as a potential threat as up-coning has been detected in well fields at a depth of 100 m as far inland as Tanta [19-21].

Barnes [27] studied the hydrosocial cycle of reuse of agriculture drainage in Egypt. In Figure 1, he illustrates the hydrosocial cycle along the Nile River. The main social aspect to be highlighted is the unofficial reuse of drainage water by the local farmers. This practice is not monitored and not considered in official water budgets as the farmer takes the decision, as Barnes mentions, intuitively. He further illustrates that in a direct conversation with a farmer in Fayoum, he has been told that farmers use their taste buds as an indicator for water quality to be reused in irrigation directly from the drain. This example sets the bar for policy makers on the type of awareness that needs to be raised on a farmer scale.

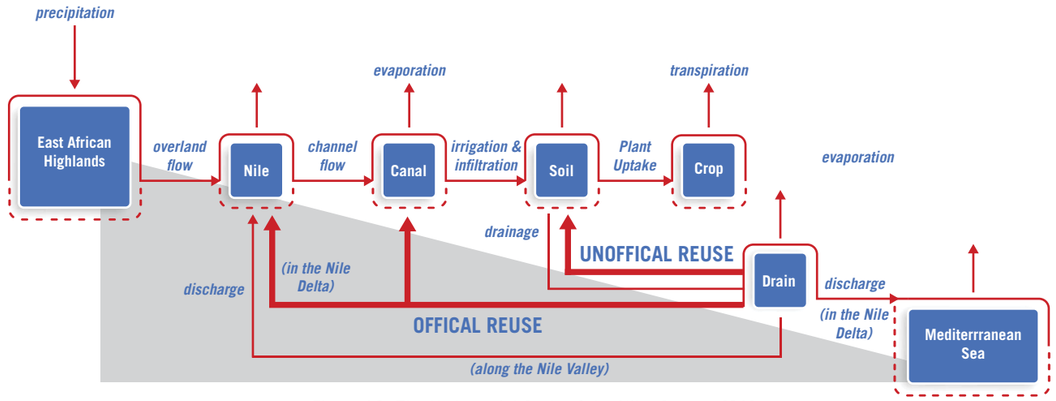


Figure 13 .The Hydrosocial Cycle of the Nile. Source: [21]

On an experimental and economical level, El Hawary & Shaban [28] studied the performance of three plant species (water hyacinth, reed, and duckweed) in the removal of drainage water pollutants in constructed wetlands. The results showed improvements in several pollution levels with costs lowest for reeds. The author consequently recommended the use of reeds for treating drainage water pollutants.

Topic 7: Water Management in Egypt

The agricultural sector consumes more than 85% of the available freshwater in Egypt [16] [29]. Given the close interrelationship between land use and water resources, water use efficiency at the farm and distribution levels are among the main water challenges in Egypt. The priority of adjusting on-farm water management (OFWM) to save and optimize the use of water resources has been clearly identified [16] [29]. Many older agriculture areas in Egypt lack appropriate irrigation technologies to increase water use efficiency of crops. In addition, the cropping patterns need to be optimized in different regions based on the available water supply considering economic, social, and environmental aspects. One of the main challenges facing modernization of irrigated agriculture is agricultural land fragmentation. This is a major trait of agriculture in Egypt, of which agricultural land is divided into relatively small plots. The average size of agricultural holdings has decreased from 6.3 feddans in 1950 to 2.1 feddans by 2000. As a result, around 12% of fertile agricultural lands is lost to the formation of boundaries between the developed holdings [30]. This makes applying modern irrigation systems and machinery economically less feasible.

Irrigation systems in Egypt distribute water among main canals and regions based on a defined volumetric quota per served region, in addition to soil and climatic conditions and cropping

patterns. However, since the control over branch canals connected to the main canals is by levels, this leads to a disparity between allocated upstream supplies and downstream demands, resulting in unequal water distribution along the canals. Some downstream users are forced to extract untreated water from nearby drainage systems to irrigate their agricultural lands [30].

Around 11 billion m³/year of irrigation water is being used in rice cultivation in the Nile Delta. "… 700,000 feddans of rice cultivation are required annually in order to prevent salt-water intrusion and to maintain soil quality," as estimated by MWRI [16] maintain food security and, at the same time control the soil salinity in the Northern Nile Delta area. In Egypt, irrigation canals are classified into three different levels; main canals, branch canals and distribution canals (Mesqas, serving up to 50 ha), see Figure 2. Improving the Mesqa performance would contribute positively to overall irrigation performance [31].

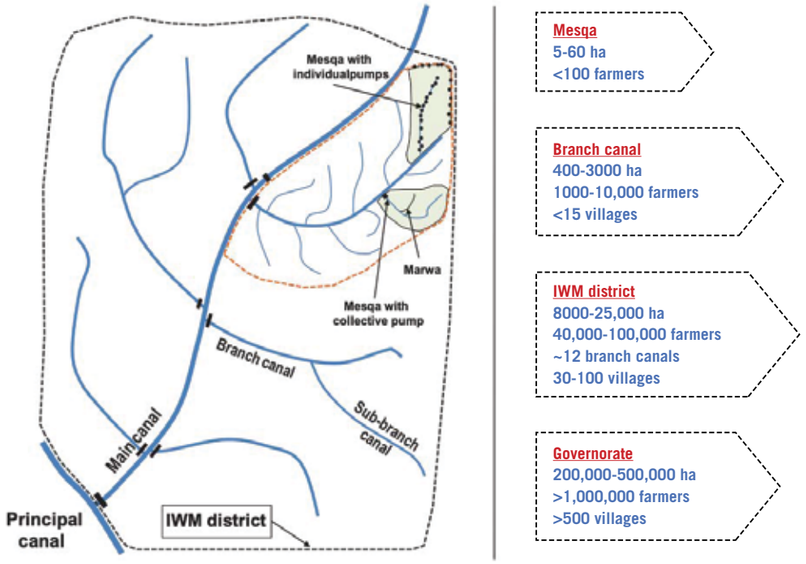


Figure 14 .Management level in Egyptian Irrigation (Nile Delta). Source: Rap, F. Molle, [31]

The economic gains of a better use of irrigation water in Egypt was studied by Gohar and Ward [32] who concluded that a 28% increase in the national farm income is expected with better allocation of water among crops, seasons, and location, even with no changes in the irrigation technologies or increase in water use.

Topic 8: Water Economics

The subsidizing of water services in Egypt in the stages of water production, treatment and distribution has encouraged excessive and unsustainable water withdrawals and inefficiency by users in the various sectors, including irrigation, municipal, industrial, navigation, and hydropower Taking the case of water-related subsidies in agriculture, possible environmentally harmful consequences arise from the wasteful use of irrigation water and promoting unsustainable decisions by farmers such as growing high water demanding crops in unfavorable conditions and using inefficient technologies. Harmful environmental impacts may include the salinization, pollution, and depletion of water resources, and raising the water table [33-35].

7.1 References

[1] Radwan. G. Abd Ellah, "Water resources in Egypt and their challenges, Lake Nasser case study" The Egyptian Journal of Aquatic Research, no. 46, pp. 1–12, 2020, doi: 10.1016/j.ejar.2020.03.001.

[2] M. N. Allam and G. I. Allam, "Water resources in Egypt: Future challenges and opportunities," Water International, vol. 32, no. 2, pp. 205–218, 2007, doi: 10.1080/02508060708692201.

[3] K. AbuZeid and M. Elrawady, "2030 Strategic Vision for Treated Wastewater Reuse in Egypt," 2014.

[4] D. Molden, "Scarcity of water or scarcity of management?" International Journal of Water

[5] Ipcc, Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel. 2007.

[6] S. Ouda, Major Crops and Water Scarcity in Egypt: Irrigation Water Management under Changing Climate. Springer, 2016.

[7] L. F. Gebre SL, "Hydrological Response to Climate Change of the Upper Blue Nile River Basin: Based on IPCC Fifth Assessment Report (AR5)," Journal of Climatology & Weather Forecasting, 2015, doi: 10.4172/2332-2594.1000121.

[8] M. S. Siam and E. A. B. Eltahir, "Climate change enhances interannual variability of the Nile river flow," Nature Climate Change, 2017, doi: 10.1038/nclimate3273.

Resources Development, vol. 27, no. 1, pp. 181–202, 2011, doi: 10.1080/07900627.2010.531522.

[9] V. Roth, T. Lemann, G. Zeleke, A. T. Subhatu, T. K. Nigussie, and H. Hurni, "Effects of climate change on water resources in the upper Blue Nile Basin of Ethiopia," Heliyon, vol. 4, no. 9, 2018, doi: 10.1016/j.heliyon.2018.e00771.

[10] E. R. Nofal, M. A. Amer, S. M. El-Didy, and A. M. Fekry, "Delineation and modeling of seawater intrusion into the Nile Delta Aquifer: A new perspective," Water Science, 2015, doi: 10.1016/j.wsj.2015.11.003.

[11] M. Hoerling, J. Eischeid, J. Perlwitz, X. Quan, T. Zhang, and P. Pegion, "On the Increased Frequency of Mediterranean Drought," Journal of Climate, vol. 25, no. 6, pp. 2146–2161, 2012, doi: 10.1175/JCLI-D-11-00296.1.

[12] J. Lelieveld et al., "Climate change and impacts in the Eastern Mediterranean and the Middle East," Climatic Change, vol. 114, no. 3–4, pp. 667–687, 2012, doi: 10.1007/s10584-012-0418-4.

[13] S. H. Mahmoud and T. Y. Gan, "Urbanization and climate change implications in flood risk management: Developing an efficient decision support system for flood susceptibility mapping," Science of the Total Environment, vol. 636, pp. 152–167, 2018, doi: 10.1016/j.scitotenv.2018.04.282.

[14] J. P. Smith, "Potential Impacts of Climate Change on the Egyptian Economy," 2012. doi: 10.1046/j.1365-2648.1995.21061033.x.

[15] A. M. Negm, Groundwater in the Nile Delta. Springer International Publishing AG 2018, 2018.

[16] MWRI, CEDARE, and A. Mohamed, "Egypt 2012 State of the Water Report," 2015.

Resources Development, vol. 36, no. 2–3, pp. 258–268, 2020, doi: 10.1080/07900627.2019.1676204.

[17] A. F. Batisha, “Cooperative Shared Water Resources Management in the Nile River Basin: the Engine for Growth Abstract”, 2011.

[18] P. S. MWRI, “Water for the Future: National Water Resources Plan 2017,” 2005.

[19] W. World Health Organization, “World Health Statistics, 2015,” 2015.

[20] World Bank, “Rural population (% of total population) - Egypt, Arab Rep.” https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?end=2018&locations=EG&name_desc=false&start=1960&view=chart (accessed Mar. 23, 2020).

[21] I. I. Ministry of Health and Population [Egypt], El-Zanaty and Associates [Egypt], “Egypt Demographic and Health Survey,” Cairo, Egypt and Rockville, Maryland, USA, 2014.

[22] S. I. El-Kowrany et al., “Water pollution in the Middle Nile Delta, Egypt: An environmental study,” Journal of Advanced Research, vol. 7, no. 5, pp. 781–794, 2015, doi: 10.1016/j.jare.2015.11.005.

[23] O. F. El-Gayar, “Aquaculture in Egypt and issues for sustainable development,” Aquaculture Economics and Management, vol. 7, no. 1–2, pp. 137–154, 2003, doi: 10.1080/13657300309380336

[24] M. T. Khalil and H. A. Hussein, “Use of wastewater for aquaculture: An experimental field study at a sewage-treatment plant, Egypt,” Aquaculture Research, vol. 28, no. 11, pp. 859–865, 1997, doi: 10.1111/j.1365-2109.1997.tb01010.x.

[25] M. Shaalan, M. El-Mahdy, M. Saleh, and M. El-Matbouli, “Aquaculture in Egypt: Insights on the Current Trends and Future Perspectives for Sustainable Development,” Reviews in Fisheries Science and Aquaculture, vol. 26, no. 1, pp. 99–110, 2018, doi: 10.1080/23308249.2017.1358696.

[26] M. A. M. Abdallah and F. A. Elmagd Morsy, “Persistent organochlorine pollutants and metals residues in sediment and freshwater fish species cultured in a shallow lagoon, Egypt,” Environmental Technology (United Kingdom), vol. 34, no. 16, pp. 2389–2399, 2013, doi: 10.1080/09593330.2013.770561.

[27] J. Barnes, “Mixing waters: The reuse of agricultural drainage water in Egypt,” Geoforum, vol. 57, pp. 181–191, 2014, doi: 10.1016/j.geoforum.2012.11.019.

[28] A. El Hawary and M. Shaban, “Improving drainage water quality: Constructed wetlands-performance assessment using multivariate and cost analysis,” Water Science, vol. 32, no. 2, pp. 301–317, 2018, doi: 10.1016/j.wsj.2018.07.001.

[29] R. El Bedawy, “Water Resources Management: Alarming Crisis for Egypt,” Journal of Management and Sustainability, vol. 4, no. 3, pp. 108–124, 2014, doi: 10.5539/jms.v4n3p108.

[30] H. Mostafa and N. Fujimoto, “Water saving scenarios for effective irrigation management in Egyptian rice cultivation,” Ecological Engineering, vol. 70, pp. 11–15, 2014, doi: 10.1016/j.ecoleng.2014.04.005.

[31] E. Rap, F. Molle, D. Ezzat Al-Agha, and W. Abou El Hassan, “The limits to participation: branch-canal water user associations in the Egyptian Delta,” Water International, vol. 44, no. 1, pp. 31–50, 2019, doi: 10.1080/02508060.2018.1554766.

[32] A. A. Gohar and F. A. Ward, “Gains from Improved Irrigation Water Use Efficiency in Egypt,” International Journal of Water Resources Development, vol. 27, no. 4, pp. 737–758, 2011, doi: 10.1080/07900627.2011.598132.

[33] A. Swain, “Défis pour le partage de l’eau dans le bassin du Nil: Évolutions géopolitiques et changement climatique,” Hydrological Sciences Journal, vol. 56, no. 4, pp. 687–702, 2011, doi: 10.1080/02626667.2011.577037.

[34] W. A. Gad, “Water Scarcity in Egypt: Causes and Consequences,” Iioab Journal, vol. 8, no. 4, pp. 40–47, 2017.

[35] S. Abdel-Dayem, “Water quality management in Egypt,” International Journal of Water.

8 Annex II: Research Needs and Capacity Report

8.1 Executive Summary

This study reports on a survey and meetings with Egyptian water experts that included questions on what they believe are the most important water-related research questions the nation faces. The overall project collected 228 online surveys from faculty and researchers at EPUs affiliated with the USAID-funded Center of Excellence, and others. Of these, eleven participated in the Research Needs Assessment and 14 laboratory managers replied to an Equipment Needs Survey. The five EPUs associated with this project and with the Center of Excellence are Ain Shams, Beni Suef, Aswan, Zagazig, and Alexandria Universities. The online survey was administered in the summer and fall of 2019 and site visits occurred during the period 9 September – 29 September 2019. The site visit regarding research potential was carried out by Dr. Bahman Sheikh, Distinguished Fellow of the Center for Integrated Water Research, at University of California, Santa Cruz. The focus was on applied research to help solve Egyptian water challenges, not important questions of theoretical research.

Although the ranking of research topics differed, a number of high-priority research needs appeared repeatedly (Table 2). These include research on desalination, wastewater treatment, water quality assessment, water pollution, water-use efficiency, ground water treatment, flash flood mitigation, and runoff water harvesting.

The survey on research capacity included questions on needed equipment in laboratories. The equipment needs most mentioned (Table 3) included spectrometer (mentioned 19 times), water quality testing meter (6), balance (4), TEM/ sounder (4), microscope (3), and autoclaves (3).

A related question asked laboratory managers to list the new or additional equipment most desired by the laboratory. There were 14 different responses listing up to 10 items, and as few as one.

Site visits included discussions with research faculty on research needs. An extended discussion at Zagazig University identified numerous issues that require additional research to arrive at solutions to Egyptian challenges. These included, among others:

- Salt-water intrusion
- Water damage to archeological locations due to seawater rise
- Collaboration among scientists and engineers about salinity of soils and groundwater
- Integration with geologists, geophysicists, and engineers, for example on flash-flood hazards
- Contamination from wastewater to groundwater, affecting potable water sources
- Treatment technologies of wastewater (biological treatment)

8.2 Introduction/ Background

As Egypt faces numerous water-related challenges, it is essential that it utilizes its impressive water-research capacity to solve or mitigate them. This study reports on a survey of Egyptian water experts that included questions on what they believe are the most important water-related research questions the nation faces. It focuses on what research should be done to help policy makers and investors understand Egypt’s water challenges better so they can take informed action.

This report also presents survey data collected at the same time on research laboratory capacity at five EPUs, as well as what new/ additional equipment is most desired to make the laboratories more effective.

The information gathered through this survey instrument in combination with onsite discussions and observations, constitute essential input to the NWRR, currently under development by the Center of Excellence. The survey reveals the opinions of some of the nation's leading water scholars on what are the most important topics requiring additional research. These findings are being combined with a detailed literature survey, study of past research planning documents, and the input of additional experts, to generate the first iteration of the NWRR.

8.3 Methodology

The Center of Excellence-Water document titled: *"Task 2.2.3: Needs Assessment Final Report – Curriculum and Teacher Training Needs",* dated April 7, 2020, provides a detailed description of the methodology used for this project, including distribution of an online survey and site visits during the period 9 September – 29 September 2019. The site visit regarding research potential was carried out by Dr. Bahman Sheikh, Distinguished Fellow of the Center for Integrated Water Research, at University of California, Santa Cruz.

The overall project collected 228 online surveys from EPU faculty and researchers, and others. Of these, eleven participated in the research needs survey and 14 laboratory managers replied to the equipment needs survey.

8.4 Survey Template (Questionnaire)

The following table shows the questionnaire used to capture information from various stakeholders on the research and infrastructure capacities.

Research Capacity Survey

Directions: This survey covers the water research laboratory you lead or work in at your university. Please fill out the information below. Each section arbitrarily has space for 10 answers. Please only use as many as needed. If you have any questions or seek clarification on this survey, please contact Brent Haddad, Ph.D., at bhaddad@ucsc.edu.

In the box below, please give your Name, Title, Campus, Email address, and relationship to the laboratory.

In the box below, please give the name of your laboratory, its location, and a brief description of its main research functions.

	How many permanent staff are employed at this laboratory?	**Provide number in next box.**	
	How many researchers are affiliated with this laboratory?	**Provide number in next box.**	

For Intensity of Use, please use the following scale:
1: Constantly in use. 2: Occasionally in use. 3: Rarely in use

	Laboratory Equipment - Please list the experimental devices or ensembles most in use in your laboratory	**Distinguishes the lab (Yes or No)**	**Intensity of use**
1			1 2 3
2			1 2 3
3			1 2 3
4			1 2 3
5			1 2 3
6			1 2 3
7			1 2 3
8			1 2 3
9			1 2 3
10			1 2 3

	Needed Equipment - Please list in order of priority the laboratory equipment needed as replacement, to upgrade, or for new research. Briefly explain the reason it is on your list.		**Replacement (R), Upgrade (U), or New (N)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

	Examples of Recent Completed or Ongoing Research Projects - Please list name and briefly describe recent water research projects undertaken at your laboratory.		**Completed (C) or In Progress (P)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Please use the following scale for the following questions:
1: Not at all. 2: Very little. 3: Somewhat. 4: To a great extent 5: Very much

1	What is your current level of Research Collaboration WITHIN YOUR Institution?	1 2 3 4 5
2	What is your desired level of Research Collaboration WITHIN YOUR Institution?	1 2 3 4 5
3	What is your current level of Research Collaboration AMONG Egyptian Institutions?	1 2 3 4 5
4	What is your desired level of Research Collaboration AMONG Egyptian Institutions?	1 2 3 4 5
5	What is your current level of Research Collaboration with foreign Institutions?	1 2 3 4 5
6	What is your desired level of Research Collaboration with foreign Institutions?	1 2 3 4 5
7	If you are currently not collaborating at the level you would like is it because of	
	Lack of Interest on your part?	Y or N
	Lack of interest on your potential collaborators part?	Y or N
	Lack of funding to facilitate collaboration?	Y or N
	Lack of recognition of collaboration effort by your institution?	Y or N
	Lack of reward for collaboration effort by your institution?	Y or N
	Lack of support for collaboration by your institution?	Y or N
	Lack of knowledge of potential collaborators within or outside your institution?	Y or N
	Your work is highly specialized and does not lend itself to collaborative studies?	Y or N
	Other reason(s) for lack of collaborative work. Please add comments below.	
8	If you are not currently involved in collaborative research are you interested in collaborative research opportunities?	Y or N

Additional Comments

8.5 Study Results and Findings

Table 7 provides answers to the main question of the research needs survey, "What are the main 5 research topics that could serve the water sector societal needs?" The question did not ask for a priority listing but are presented here in the order they were listed on the survey instrument.

Respondent	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
1	Desalination	Wastewater Treatment	Nano Materials in Wastewater	NA	NA
2	Runoff Water Harvesting	Desalination	Groundwater Modeling	Flash Flood Mitigation	Water Quality
3	Water Quality Assessment	Water Pollution	Groundwater	NA	NA
4	Water Quality Evaluation and Monitoring	Wastewater Remediation	Desalination	Fate & Transport of Contaminants in Water	Removing Microplastics
5	Water Management	Desalination	Groundwater	NA	NA
6	Water Pollution	Wastewater Treatment	Groundwater Treatment	Sustainable Drinking Water	Water Salinity & Safety
7	Water Pollution	Wastewater Treatment	Water Quality	Groundwater Treatment	Desalination
8	Wastewater Treatment	NA	NA	NA	NA
9	Desalination	Renewable Energy	Water-use Efficiency	Water Economics	NA
10	Water Desalination	Water Treatment	Water Quality Monitoring	Brackish Groundwater	NA
11	Wastewater Treatment	Water-use Efficiency	Water Harvest	Flash Flood Risk Assessment	NA

Table 7. Five top water research needs to serve Egyptian society: Survey Results

Table 8 provides a rank ordering of the research topics mentioned more than once. Desalination was mentioned seven times, followed by Wastewater Treatment which was mentioned six times.

Research Topics	Times Listed	Notes
Desalination	7	also, Water Salinity and Safety
Wastewater Treatment	6	
Water Quality Assessment	5	
Water Pollution	3	
Water-use Efficiency	2	
Groundwater Treatment	2	
Flash Flood Mitigation	1	also Flash Flood Assessment
Runoff Water Harvesting	1	also, Water Harvest

Table 8. Ranking of research topics

Because the survey asked only for water topics and not for details, each denotes very broad research areas. This is especially notable with "water pollution," though with all topics, the actual research project would of course need to be focused on problems or issues experienced in Egypt.

A related question asked Laboratory Managers to list the new or additional equipment most desired by the laboratory. There were 14 different responses listing up to 10 items, and as few as one. Table 3 lists the priority ranking of requested laboratory equipment. The major finding of this question was the desire for additional spectrometers. Spectrometers are instruments that provide detailed description of the chemical contents of water by examining how light passes through the water sample. They are used in research involving water quality and treatment. The next largest set of equipment were other water quality testing meters. In addition to water quality testing, which dominated the list, there were also requests for groundwater detection and measurement devices, as well as water treatment equipment (reverse and forward osmosis), including both systems and system testing equipment. It should not come as a surprise that water Laboratory Directors would focus on water quality-related equipment as their most needed additions.

Unit	Mentions	Notes
Spectrometer	19	Multiple types mentioned
Water Quality Testing Meters	6	Numerous types
Balance	4	Weighing samples
TEM/ Sounder	4	Groundwater measurements
Microscopes	3	3 different types mentioned
Autoclave	3	Sterilizer
Incubators	2	Sampling for biological contaminants
Laminar Flow Cabinet	2	Prevents contamination of laboratory
Thermostat-shaker/ Shaker	2	Sample preparation
Water Bath	2	Temperature control of test tube
Forward/ Reverse osmosis	2	Both units and testing equipment
Microwave Digestion	2	Prepares samples for spectrometry
PCR	2	Biological water quality testing

Table 9. Most requested new/additional units by water laboratory managers

Notes: TEM – Time-domain Electro-Magnetic sounding device; PCR – Polymerase Chain Reaction

8.6 Additional Findings from Site Visits

Following site visits to Alexandria, Zagazig, and Beni Suef Universities, Dr. Bahman Sheikh encouraged research into topics of importance to the sustainability of water resources and their safe yield. Applied research related to integrated management of water resources and water allocation are critical issues. Faculty at Zagazig University discussed possible research projects with Dr. Sheikh. Following is a subset of those topics emphasizing applied research.

- Salt-water intrusion
- Water damage to archeological locations due to seawater rise
- Collaboration among scientists and engineers about salinity of soils and groundwater
- Integration with geologists, geophysicists, and engineers, for example on flash-flood hazards
- Contamination from wastewater to groundwater, affecting potable water sources
- Treatment technologies of wastewater (biological treatment)
- Production of energy from organic contaminants in oil production wastewater
- Dams and other hydraulic structures, their failures
- Water quality management
- Construction of dams—water management and distribution
- Application of geophysical tools to determine aquifer parameter
- Imaging saltwater intrusion and wastewater seepage into the aquifer
- Conjunctive use of ground and surface water in the Sinai desert (near *Sharm el Sheikh*)
- Upgrading of irrigation systems from flood irrigation to new methods (drip irrigation and subsurface irrigation)
- New cultivars that consume low water amounts
- Role of weather stations to measure the real-time need of crop water from weather-station data
- Study of industrial wastewater discharges to surface waters and the need for their separate treatment and proper disposal
- Research into the affordable ways to remove salts from brackish groundwater

The above list was elicited as being of interest to the Zagazig faculty and indicates the interest of faculty in pursuing applied research of benefit to Egyptian society.

8.7 Acknowledgements

The survey was coordinated by Utah State University, led by Dr. Kurt Becker. The tables in this report were co-produced by Professor Brent Haddad and UCSC Doctoral Candidate Stephanie Webb.

9 Annex III: Training Needs Assessment Report

9.1 Introduction/ Background

There is a growing need to strategically tackle the impending water crisis facing Egypt. Significant improvements are required in the water sector ranging from infrastructure development to upgrading technical know-how which would help to face the current challenges and provide the grounds for sustainable growth for the people. Egypt's Vision 2030 categorically outlines the path for economic growth through knowledge and innovation. Water plays a pivotal role in meeting the needs for agriculture, industry and public consumption which has significant socio-economic impacts. Hence, education in the water science is critical to build capacity to harness technical expertise in the water sector for the researchers and engineers towards solving the water related challenges.

This report analyzed the survey results which identified priority research areas, curriculum and professional development needs along with training requirements in the water quality and treatment methods. The survey represents the needs of the students, academic faculty and representatives from the non-academic sector which can be improved through the various training and exchange programs with the US partnering Universities. The survey was conducted in the five Egyptian Partner Universities (EPUs) - Ain Shams, Beni Suef, Aswan, Zagazig, and Alexandria Universities along with the Center of Excellence (CoE) for Water.

9.2 Methodology

The data collection was coordinated by USU, in association with CoE for Water for conducting a Needs Assessment Analysis for the current status of water engineering in Egypt. The detailed methodology can be found in the CoE Water document[1]. The survey comprised participants from Egyptian faculty, researchers, and others from non-academic sectors.

9.3 Study Findings

9.3.1 Professor/Academic Skills Need Survey

The survey results for evaluating the list of professional development needs pertaining to importance in teaching and interest in attending training/workshops are presented in Figure 1. At least 50-70% of the faculty have given the maximum score to each topic while the mean score remains still higher around ~80% (data not shown) for each topic. It clearly highlights that applied research in water treatment is essential for their professional development and are interested in attending the training. There was also significant interest in research commercialization and entrepreneurship which was considered important for their professional development and expressed interest in attending workshop/webinar trainings. Specific aspects outlined which should be taught in a workshops/webinar are as follows:

- Water treatment technologies
- New lab instruments for water quality assessment
- Research to business model
- Technology licensing practice-IP protection
- How to find and apply for research funding, inventions, and commercialization

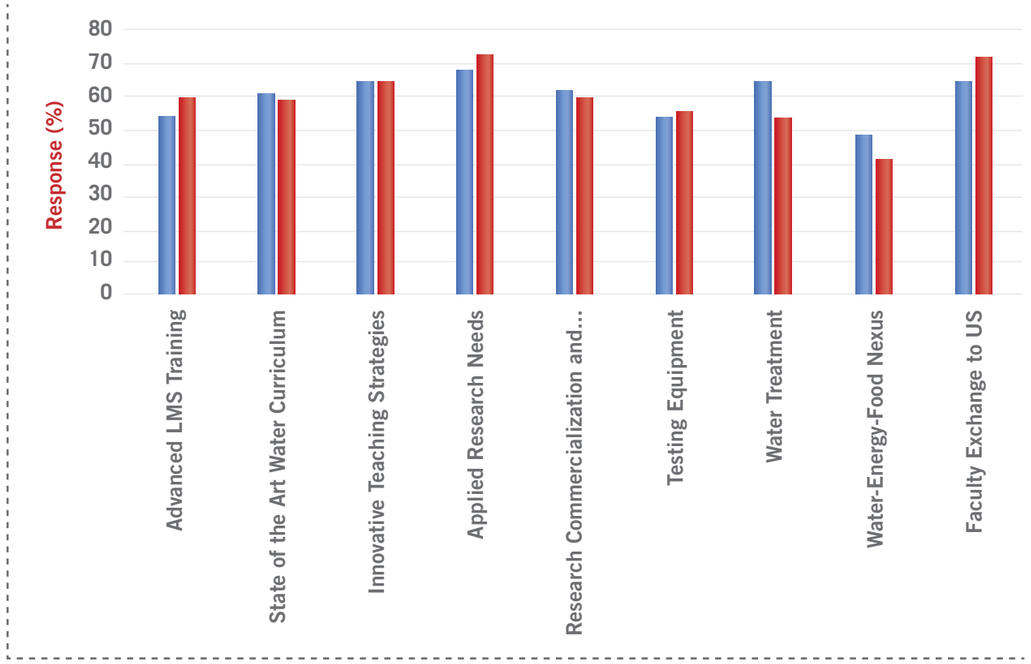


Figure 15. Survey data to evaluate the list of professional development needs in terms of importance and interest in attending workshops/trainings. Data shows the percentage of respondents giving maximum score in each category (5 important, 1 not important)

The survey further evaluated by asking for the priority ranking of the 5 most important applied research topic titles among the respondents. Table 1 enlists the top ten topics in each of the categories. 85% of the respondents indicated the need for applied research topics research topics encompassing but not limited to water and wastewater treatment, water quality, advanced treatment technologies, pollutant fate and transport, water reuse, water resource management, environmental impact assessment, desalination, and other water/wastewater related topics.

The explanation for enlisting the topics and their reason for being a priority has also been documented. It includes, ranging from being deemed very essential for water requirements in Egypt to advanced water treatment technologies. Other reasons include better water resource management, reuse of agricultural water, cost-effective techniques to provide high quality potable water and mitigate water scarcity and monitoring water pollution.

Applied Research Topic-1	Applied Research Topic-2	Applied Research Topic-3
Water Treatment	Desalination	Environmental Chemistry of Water
Monitoring of pollutants in surface and groundwater	Using satellite technology and remote sensing techniques for groundwater exploration	Risk Assessment
Enviromental Impact Assessment	Water and Environmental Analysis	River-bank Filtration
Wastewater Treatment	Transboundary Water Resources	Upgrading wastewater treatment plants
Assessing water quality parameters using remote sensing techniques	Planning of water evaluation and monitoring program for the agricultural sector	Wastewater Treatment
Identification of water constituents	Renewable Energy	Water Quality
Reuse of Wastewater	Removal of organic pollutants	Modern irrigation and agriculture techniques
Biological Water Treatment	Biogas from wastes	Provide high quality potable water
Desalination	Utilization of microalgae for energy production from high nutrients wastewater treatment	Stability of dams, and dam failure effects on downstream countries
Removal of heavy metals by nanoparticles from industrial wastewater	Water Reuse	Fighting Water scarcity
Reuse of wastewater for greening the desert	Biogas production from industrial wastewater	Energy efficient hybrid treatment units based on sulphate radicals coupled with simple membrane treatment systems for efficient wastewater
Enhancing water use efficiency in irrigated areas	Low-cost nanomaterials for remediation of emerging organic contaminants in soils and wastewater	Treatment and disinfection for reuse
Integrated management of water resources in dry areas	Water management	Remediation of wastewater using locally derived biochar purifiers
Water management in agricultural	Management of underground aquifers in dry areas	Cost effective water treatment technologies
Sustainability	Reuse of Industrial wastewater	Ground water

9.3.2 The Research Capacity Analysis Survey

The researchers have indicated an overwhelming desire to engage in applied research leading to practical application and solutions to water science and engineering problems. 43% of the researchers have reported technology development which resulted in commercial applications and more would like to see technology which can be commercialized by the industry.

Table 2 outlines the most important research needs survey question pertaining to 5 main research topics that could serve the water sector societal needs. Topics were not asked to mention as a priority list hence the table represents a compilation from the survey as listed. The most mentioned research topics in terms of enlisted frequency are desalination, wastewater treatment, water quality assessment, water pollution and water use-efficiency.

Respondent	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
1	Desalination	Wastewater Treatment	Nano Materials in Wastewater	NA	NA
2	Runoff Water Harvesting	Desalination	Groundwater Modeling	Flash Flood Mitigation	Water Quality
3	Water Quality Assessment	Water Pollution	Groundwater	NA	NA
4	Water Quality Evaluation and Monitoring	Wastewater Remediation	Desalination	Fate & Transport of Contaminants in Water	Removing Microplastics
5	Water Management	Desalination	Groundwater	NA	NA
6	Water Pollution	Wastewater Treatment	Groundwater Treatment	Sustainable Drinking Water	Water Salinity & Safety
7	Water Pollution	Wastewater Treatment	Water Quality	Groundwater Treatment	Desalination
8	Wastewater Treatment	NA	NA	NA	NA
9	Desalination	Renewable Energy	Water-use Efficiency	Water Economics	NA
10	Water Desalination	Water Treatment	Water Quality Monitoring	Brackish Groundwater	NA
11	Wastewater Treatment	Water-use Efficiency	Water Harvest	Flash Flood Risk Assessment	NA

Table 11. Survey results for the top five research needs to serve Egyptian society

The results for the research capacity analysis survey for the list of research skills needed are outlined in Figure 2. An overwhelming majority identified the importance and need for skills in applied research, commercialization, equipment testing and proposal preparation while indicating interest in attending workshops.

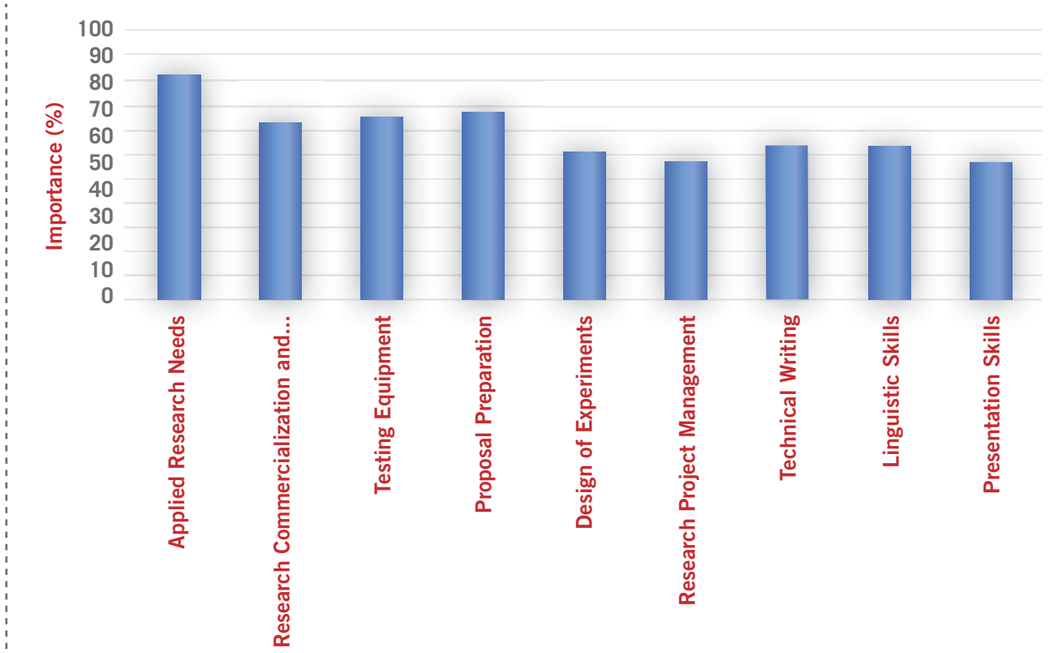


Figure 16. The results for the research capacity analysis survey for the list of research skills needed (5 important, 1 not important)

Another survey question asked laboratory managers to list the most desired new or additional equipment's for the labs (Table 3). The compiled table list the equipment's in terms of priority ranking and clearly illustrates the significant research and analytical focus on water quality testing and treatments in terms of equipment end-use. In addition, during personal interviews at Alexandria University (AU), there were faculty who expressed a strong need for advanced equipment – **Gas chromatograph /mass spectrometer (GC/MS) and liquid chromatograph /mass spectrometer (LC/MS)**. These equipment are very common in the US university water quality and treatment technology labs and are considered standard equipment. Several AU faculty showed their research publications and student dissertations to justify the need for these equipment. There is a lab at AU which houses an Atomic Absorption unit for analysis of metals and is managed as a cost center lab. Another important equipment is an **Ion Chromatograph (IC)** to analyze for anions such as chloride, sulfate, nitrates etc. It is recommended that a lab be setup at AU which houses LC/MS, GC/MS and IC instruments and available for use for all member Egyptian universities and research organizations. These instruments are also listed in Table 12.

9.3.3 Non-Academic Organization Needs Analysis Survey

The survey results for identifying areas of importance have been outlined in Table 4. It included advanced Water and Wastewater Treatment for Reuse, Improving Water Productivity and Water Use Efficiency within the Water-Food-Energy Nexus, Environmental Impact Assessment in Water Engineering Projects, Pollution Prevention and Industrial Ecology. They indicated significant desire for collaborative opportunities with the universities in areas ranging from ground water, applied research, water resources and surface hydrology, water and process water treatment from industrial chemicals, river engineering and water resource.

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
Modern Irrigation Systems	Potable Water Management	Sewage Water	Rain Harvesting	Surface Water Management
Alternate Sources of Fresh Water	Sustainable Water Resources Projects	Environmental Impact Assessment of water projects	Green Infrastructure	Maximize the use of rainwater
Industrial wastewater treatment via nano-metals	Groundwater use at remote areas	Groundwater Bioremediation	Soil Treatments	Innovative Farming Techniques
Treatment	Desalination	Drainage	Groundwater	Hydrogeology
Water Resources Management	Groundwater Resources Management	Rainwater Harvesting	Renewable Water Resources	Surface Water Management
Water Treatment	Hydrology	Sustainability	Hydraulics	Maximize the use of rainwater

Table 13. Survey results for the priority ranking of the top five applied research topics.

The importance and need for the research topic explicitly identified various reasons, some relates to lack of industrial water treatment for contaminants which could create public health hazards. Other reasons enlisted were maximizing water resource use and incorporation of modern systems to treat wastewater.

9.4 Additional Findings from Site Visits

The site visits broadly comprised of three areas for each EPU:

- Teaching and Learning
- Equipment and Software
- Research Support

Professional development includes faculty exchange to aid in the learning and gaining experience in the various topics of interest previously discussed with respect to the on-line survey analysis. There is also a need to develop additional funding sources for research. In addition, specific interest in applied research related to management and sustainability of water resources and water quality was identified. Some of the topics pertaining to applied research, more specifically coming from the Zagazig University faculty are:

- Contamination from wastewater to groundwater, affecting potable water source
- Treatment technologies of wastewater (biological treatment)
- Water Quality Management
- Harnessing energy from organic contaminants present in oil production wastewater
- Desalination
- Industrial wastewater treatment and effective disposal strategies/methodology to surface water

9.5 References

[1] Needs Assessment Final Report – Curriculum and Teacher Training Needs, dated April 7, 2020.

10 Annex IV: NWRR Change Request

NWRR Change Request			
Request Date			
Request submitted by (full name, designation, and entity)			
NWRR Version Number			
Change Reference Number (page and numbering)			
Current Description			
Suggested Change/ Description* (please attach any addition-al change related supporting documents to this form)			
Reason for Suggestion:	☐ Results of research undertaken in the previous year	☐ New information on the challenges Egypt faces	☐ Expert feedback on the NWRR
	☐ Research that adds insights into the analysis made in the current version	☐ Changing National Priorities	☐ Other:

Reviewed and Approved By:

Designation	Name	Signature	Date
Research and Policy Committee - Chairman			