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NEPAD Networks of Centre of Excellence in Water Sciences PHASE II

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Human Capacity Development Component: Phase II

Piloting

Final Report

Contents

List of tables

List of figures

Accompanying folders/reports

Course materials

1. Malawi
   1.1 Hydrological Modelling & Water Quality Modelling
   1.2 Water and Sanitation Systems
2. Mozambique
   2.1 Management and Maintenance of Networks and Water Loss
   2.2 Environmental Impact Assessment
3. South Africa – CSIR
   3.1 Environmental Assessment and Management - IWRM and the Workplace
4. South Africa – UWC
   4.1 Water Demand Management & Water Security
   4.2 Introduction to Groundwater Hydrology
5. Zambia
   5.1 Hydrogeology and Drilling Supervision Training

M&E Report

Acronyms and Abbreviations

AMCOW	:	African Ministers' Council on Water
BGR	:	Federal Institute for Geosciences and Natural Resources
CEFPAS	:	Water and Sanitation Training Centre (Mozambique)
CoE	:	Centres of Excellence
CSIR	:	Council for Scientific and Industrial Research
DNGRH	:	National Directorate for Water Resource Management (Mozambique)
DWS	:	Department of Water and Sanitation (South Africa)
EWSETA	:	Energy and Water Sector Education and Training Authority
GIZ	:	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GWPSA		Global Water Partnership Southern Africa
HCD	:	Human Capacity Development
IIA	:	Water Research Institute (Mozambique)
INIR	:	Irrigation National Institute (Mozambique)
IWRM	:	Integrated Water Resources Management
JSPTL	:	Junior/senior Professional and Technician level
M&E	:	Monitoring & Evaluation
NEPAD	:	New Partnership for Africa's Development
SETSADC	:	Southern African Development Community
SADC SHCDP	:	SADC Strategic Human Capacity Development Plan
SADC-WD	:	SADC - Water Division
SANWATCE	:	Southern African Network of Water Centres of Excellence
ToT	:	Training of Trainers
TEVETA	:	Technical and Vocational Education and Training Authority
TVET	:	Technical and Vocational Education and Training

UEM	:	Universidade Eduardo Mondlane
UNIMA	:	University of Malawi
UNESCO-IHP	:	United Nations Educational, Scientific and Cultural Organization Intergovernmental Hydrological Programme
UNZA	:	University of Zambia
UWC	:	University of the Western Cape
WARMA	:	Water Resources Management Authority (Zambia)
WASAMA	:	Water Services Association of Malawi (WASAMA)

1. Introduction and project background

The Human Capacity Development (HCD) Component of the ACEWater2 project implements the African Ministers Council on Water (AMCOW) declaration urging the African Union Commission and NEPAD Centres of Excellence to develop a “Human Capacity Development Programme for junior/senior professional and technician level (JSPTL) capacity challenges in the water sector” at the national level in the Centres of Excellence countries. The project, Human Capacity Development Component for Southern African NEPAD Water Centres of Excellence, is funded by the European Commission, coordinated by UNESCO-IHP and implemented by the African Network of Water Centres of Excellence. In southern Africa, the HCD component supports the preparation of national human capacity development frameworks/strategies/plans that address junior professional and technician level capacity challenges in five NEPAD Centres of Excellence (CoE) countries. These pilot countries include Botswana, Malawi, Mozambique, South Africa and Zambia. The national HCD frameworks include an implementation plan and a monitoring and evaluation (M&E) framework. Phase I of the HCD component was implemented in 2017 and 2018 under IPA 1, while Phase II was implemented between 2018 and 2020 under IPA 2. This Deliverable presents the final report for the Phase II and includes a synthesis of IPA 1.

2. Phase I

Phase I supported the preparation of frameworks on Human Capacity Development addressing junior/senior professional and technician level capacity challenges in five NEPAD CoE countries in southern Africa namely: Botswana, Malawi, Mozambique, South Africa, and Zambia, including an implementation plan together with a monitoring and evaluation (M&E) framework.

2.1. Project objective

The objective of the HCD component was to establish a national Human Capacity Development Programme addressing junior/senior professional and technician level capacity challenges in at least five NEPAD CoE Countries from southern Africa. Specifically, Phase I sought to:

i. Support the CoE at national level in five countries in identifying needs and defining priorities with national governments through a multi-stakeholder participative approach.

   Activities
   - Study on sector needs at national level including consultation of national partners and stakeholders.
   - Organisation and implementation of national dialogue for capacity building in the water sector with all stakeholders and partners: Defining priorities from the needs.
   - Designing and validation of a national strategy for capacity building in the water sector
   - Organisation and facilitation of a national validation workshop

ii. Define an implementation framework together with an M&E framework

Activities
- Identification of priorities for the implementation framework with partners and stakeholders in the framework of the national dialogue for capacity building in the water sector
- Design of a national implementation framework for capacity building in the water sector
- Identification, formulation and validation of the M&E framework with partners and stakeholders in the framework of the national dialogue including sector indicators.

2.2. Country processes and outcomes

National consultation meetings – dialogue and validation workshops - were conducted from July 2017 until April 2018 as shown in table 1 below.

Table 1: Country stakeholder engagements

Country	Dialogue dates	Validation workshop dates
Botswana	13 September 2017	12 April 2018
Malawi	28 July 2017	02 February 2018
Mozambique	25 August 2017	Beira - 14 March 2018 Maputo – 16 March 2018
South Africa	21 September 2017	22 February 2018
Zambia	23 August 2017	31 January 2018

2.3. Key findings - common gaps, needs and priorities in human capacity development

Most of the countries noted the following issues:

- National policy and legislative frameworks in the 5 countries acknowledged the importance of human capacity development in the water sector. In Malawi and Zambia for instance, legislation (Water Resources Act of 2013 and Water Resources Acts of 2011 respectively) state that funding for HCD in the water sector is to be financed from water abstraction levies through relevant water authorities. Yet, this was not in effect as relevant institutions to implement said provision have either not been formed as yet or are not fully functional. Overall, the challenges lie in the implementation of the policy or strategy as well as the lack of clearly defined focus on JSPTL in the water sector.
- National HCD initiatives – HCD capacity analyses - previously undertaken in the countries were not necessarily demand-responsive. Courses were developed and undertaken as part of donor-led/driven activities and not always in response to sector needs. As such, results and outcomes have, generally, not been institutionalised and therefore not sustained.
- There is inadequate connectedness and collaboration between many key institutions. In particular, capacity building institutions (CBIs) and government as well as the CBIs and industry (including the water boards/utilities and private sector)
- Most tertiary institutions often only offer academic programmes that do not address the skills required by industry. Thus, university graduates were felt to not possess requisite technical skills to accompany academic qualifications hence not job-ready.
- While a host of Technical and Vocational Education and Training (TVET) institutions exist, programmes offered there do not adequately cater for the skills needed in the water sector.
- There were non-existent or inadequate internship and mentorship initiatives for students to ensure job-ready personnel at graduation.

Most prioritised actions, as such, were aimed at addressing the above needs. The following were common recommendations in the countries:

- To address implementation issues in HCD in the water sector.
- To ensure that JSPTL targeted programmes are emphasised.
- To recognise experienced skilled personnel despite not having formal qualifications through recognition of prior learning.
- To attend to the gaps and weaknesses in water related programmes at capacity building institutions especially at TVET institutions
- To foster greater collaboration between CBIs, as well as formalised collaboration among CBIs, government and industry – especially water utilities and private sector - to ensure that HCD initiatives respond to the needs of the sector and development context of the country. Such collaborative arrangements include placement of students and recent graduates for internship and apprenticeship at relevant institutions.
- The ministry responsible for water as the sector lead needs to own, drive and be the champion of the HCD efforts in the water sector.
- The HCD initiative at the national level must be housed in the lead ministry with linkages to other government ministries such as labour and education. This will ensure that the HCD initiatives are within government policy and strategic frameworks as well as being responsive to the real pressing needs.
- Challenges and gaps in existing curricula of CBIs (including TVET institutions) require targeted institutional strengthening (or revival) of CBIs and the courses they offer.
- Countries acknowledged the importance of developing relevant, stakeholder informed HCD frameworks/plans to target specific donors and national budgeting processes to implement priority HCD initiatives.

Country specific outputs and outcomes are presented in table 2 below.

Table 2: Summary of country specific outputs and or outcomes from national processes

<table>
<tr><th>COUNTRY</th><th>SIGNIFICANT ACHIEVEMENT AND/OR OUTCOME</th></tr>
<tr><td>BOTSWANA</td><td>The Department of Water Affairs (DWA) supports the placement of HCD process and output in the National Human Resource Development (HRD) strategy (Realising our potentials). The DWA will lead the formal engagements with the sector committee for Mining, Minerals, Energy and Water Resources (MMEWR) that is responsible for the water sector human capacity development.
For the University of Botswana, the national process was of strategic benefits for the University of Botswana and helped in strengthening the position of the University as a water CoE in the area of water resources management and development.

Prioritised trainings
<table>
<tr><td>Junior profession level</td><td>Advanced hydrology
Water resources management</td></tr>
<tr><td>Technician level</td><td>Applied and field hydrology for practitioners
Principles of Hydrology for Technicians and Artisans</td></tr>
</table>
</td></tr>
<tr><td>MALAWI</td><td>The Department of Water Resources (DoWR) in the Ministry of Agriculture, Irrigation and Water Development, Ministry of Education, capacity building institutions and water boards demonstrated ownership of the process of formulating the HCD strategic framework. Given the confirmed urgent need of HCD for junior/senior professional and technicians, stakeholders will most likely invest further energy into leveraging resources to implement the framework in the short and long term.</td></tr>
</table>

<table>
<tr><td></td><td>Prioritised trainings<table><tr><td>Junior professional level</td><td>Water Quality Modelling
Hydrological modelling</td></tr><tr><td>Technician level</td><td>Water Supply
Water and Sanitation Systems
Certificate programme for Water Technicians
Apprentice Diploma Programme for Water Technicians</td></tr></table></td></tr>
<tr><td>MOZAMBIQUE</td><td>The national process in Mozambique resulted in the development of a Capacity Building Strategy for Junior Professional and Technician Personnel in the Water Sector led by the Ministry of Science and Technology, Higher Education and Technical Training. As of the date of this final report, The Strategy will still have to go through cabinet processes for approval before coming into effect in the country.

Prioritised trainings<table><tr><td>Junior professional level</td><td>Management and Maintenance of Networks and Water Loss
Community Education</td></tr><tr><td>Technician level</td><td>Environmental Impact Assessment
Water Quality Management</td></tr></table></td></tr>
<tr><td>SOUTH AFRICA</td><td>The national process provided room for a discussion on the effectiveness of existing HCD initiatives in the country. The process highlighted the existence of numerous HCD efforts by various stakeholders that include national government, water utilities, CBI, sector education and training authorities (SETAS). Yet, a gap exists with the monitoring, evaluation and reporting of HCD programmes. Thus, the thrust of the HCD component focuses on the need to develop a monitoring, evaluation and reporting framework. The process of developing the monitoring, evaluation and reporting framework for South Africa is to be led by the Department of Water and Sanitation as well as the Energy and Water Sector Education and Training Authority (EWSETA).

However, it is to be noted that courses implemented for South Africa under Phase II were identified from a desk-study and consultations during the scoping studies under IPA 1. For South Africa, the HCD component fell within the fifth implementing area of the National Water Resources Strategy (II): water sector skills and capacity. This addresses 7 strategic themes as follows: 1) water resources planning, development and infrastructure management; 2) water resource protection; 3) equitable water resources; 4) water conservation and water demand management; 5) managing water resources for climate change; 6) regulation of the water sector; and 7) international and transboundary water resource management. The courses offered by the UWC and CSIR also complemented the Framework Programme for Research, Education & Training in the Water Sector (FETWater III) initiative implemented by the South African Department of Water and Sanitation through the Water Research Commission.</td></tr>
<tr><td>ZAMBIA</td><td>The focus of national process responded directly to the human capacity development needs to implement legislative and policy frameworks for the Ministry of Water Development, Sanitation and Environmental Protection, in particular the Water Resources Management Authority (WARMA) and the new Department of Water Resources Development (DWRD). The HCD component, therefore, makes a contribution towards the formulation of a national plan on recognition of prior learning as well as occupation qualifications and technical skills training for the water sector.

Prioritised trainings<table><tr><td>Junior professional level</td><td>Water resources monitoring
Water Environmental quality modelling</td></tr></table></td></tr>
</table>

		Technician level	Hydrogeology and Drilling Supervision Training Field hydrogeology

Overall, the process of developing the human capacity development programmes confirmed the need for concerted effort to address junior profession and technician level capacity challenges for sustainability of water as a resource and water supply and sanitation services provision. Developing such a programme requires engagement and support of both tertiary and TVET institutions, national water and education institutions including water utilities and the private sector. The stakeholder dialogues led to the development of HCD frameworks or conversations that are meaningful, well placed in the regional and national institutional and policy framework and most importantly identified priority actions to address real human capacity challenges of the water sector. Validation works generated sufficient ownership of the frameworks. With further minimal support, components of HCD frameworks/plans can be implemented to demonstrate action and results. In addition, the HCD frameworks/plans can be used to leverage additional resources (both internally through the national budget and the private sector as well as through bilateral funding) for implementation of the priorities in short and long term. Thus, these stakeholders developed programmes not only address the national HCD needs and resultant prioritised actions but are also most likely to be taken forward and continue within national processes.

3. Phase II

The second phase of the HCD component involved the implementation of the Human Capacity Development Programmes in up to four countries in southern Africa in collaboration with relevant institutions fostering sustainable capacity development approach. Specifically, activities in this phase included:

i. Support the implementation of the National Frameworks on human capacity development in at least three countries:
   Activities
   - Wide dissemination of national frameworks to at least 30 partners and key stakeholders.
   - Purchase of software and consumables for laboratories or tools for numerical computational modelling.
   - Preparation and delivery of four training courses prepared in at least three countries.

i. Manage an exchange programme for students and researchers within the NEPAD Southern Africa Network of Centres of Excellence and, where feasible, with the other NEPAD Networks of Centres of Excellence in West and Central / East Africa
   Activities:
   - Signing of agreements between universities for the exchange programme including topics or objectives of the exchange.
   - Facilitate up to 10 students or researchers complete visiting or research exchanges within the sub-region.

Table 3 presents an overview of Phase II implementation.

Table 3: Overview of Phase II implementation

Activity	Progress & reason for deviation where necessary
Wide dissemination of national frameworks to at least 30 partners and key stakeholders	National frameworks disseminated at various fora by CoEs in Malawi, Mozambique, South Africa and Zambia. Dissemination is considered an ongoing activity given the need for cabinet approval in Mozambique for example or ongoing discussions and activities with different stakeholders to implement the frameworks as in Malawi and Zambia for instance. This contributes to the sustainability and continuity of the project activities beyond the project timeline.
Purchase of software and consumables for laboratories or tools for numerical computational modelling	Purchase of software and consumables at Universities of Malawi and Universidade Eduardo Mondlane *Reason for deviation:* COVID-19 affected the role out of activities at other institutions (Council for scientific and Industrial Research, University of the Western Cape and University of Zambia)
Preparation and delivery of four training courses prepared in at least three countries;	Seven (7) courses implemented by University of Malawi (UNIMA), Universidade Eduardo Mondlane (UEM), Council for Scientific and Industrial Research (CSIR), University of the Western Cape (UWC) while one course was developed but not implemented by UNZA *Reason for deviation:* 17 courses initially planned for face-to-face delivery at UB, UNIMA, UEM and UNZA. However, as a result of the COVID pandemic, UB opted out and CSIR and UWC opted in. Consequently, 20 courses in total were developed. 7 courses offered, and one course fully developed but not offered (due to project timelines) at five institutions and delivery included online learning.
Signing of agreements between universities for the exchange programme including topics or objectives of the exchange	November 2019 – April 2020 *Reason for delay:* knock on effect of the delayed start of the country processes coupled with unavailability of CoEs personnel working on the project (academic commitments and end of year slow down).
Facilitate up to 10 students or researchers complete visiting or research exchanges within the sub-region	1 student exchange conducted by a student from UNZA to UWC. *Reason for deviation*: exchange programme cancelled as a result of travel restrictions due to the COVID-19 pandemic.

Botswana opted out of implementing activities in this phase, in part because of the disruptions brought upon by the COVID-19 pandemic. Reporting on Phase II therefore covers Malawi, Mozambique, South Africa and Zambia. Even though Botswana opted out, it still provided detailed course contents (see Annex 1 on SANWATCE detailed course contents), for courses on Advance Hydrology; Water Resources Management; Applied and Field Hydrology for Practitioners; Principles of Hydrology for Technicians and Artisans.

3.1. HCD Framework dissemination

The process of disseminating human capacity development programmes was an ongoing activity since their validation in 2018. As part of Phase II (20 August 2018 – 15 November 2020), CoEs were to:

> Disseminate national frameworks and implementation frameworks to stakeholders, donors and training institutions at national level including:

- Preparation of dissemination materials, including publishing the National HCD Frameworks of the Pilot Countries into information packages for distribution in each of the Pilot Countries.
- Dissemination of the frameworks in the network of institutions relevant to the water sector for vocational and professional level, *including a national workshop.*
- Dissemination of the frameworks to sector stakeholders including donors.

Activities conducted are presented below.

3.1.1. Malawi

Through the consultation process in Malawi (during Phase I), the Department of Water Resources (DoWR) in the Ministry of Agriculture, Irrigation and Water Development, Ministry of Education, capacity building institutions and water boards demonstrated ownership of the process of formulating the HCD strategic framework. Given the confirmed urgent need of HCD for junior professional and technicians, stakeholders leveraged resources to implement the framework.

The HCD framework has been disseminated to key stakeholders in the water sector including water boards, higher education institutions and non-governmental organisations as shown in Table 4 below. In accordance with IPA 1, IPA 2 and as mentioned earlier, dissemination of the HCD Framework was an ongoing process since their validation in SANWATCE and in Malawi, it has reached at least 30 partners and stakeholders since 21 stakeholders were reached at the validation workshop on the 2nd of February 2018, followed by another 12 stakeholders reached through the engagement shown in Table 4.

Table 4: HCD framework dissemination in Malawi

	Stakeholder	Activity	Date
1	Lilongwe Water Board	Meeting to share strategy, internship and joint teaching	10 July 2019
2	Blantyre Water Board	Meeting to share strategy, internship and joint teaching	12 July 2019
3	Northern Region Water Board	Meeting to share strategy, internship and joint teaching	20 August 2019
4	Central Region Water Board	Meeting to share strategy, internship and joint teaching	22 August 2019
5	Southern Region Water Board	Meeting to share strategy, internship and joint teaching	30 August 2019
6	Mzuzu University	Meeting on joint teaching and research and research and curriculum review	19 August 2019
7	Malawi University of Science and Technology	Meeting on joint teaching and research and research and curriculum review	31 July 2019
8	Lilongwe University of Agriculture and Natural Resources	Meeting on joint teaching and research and research and curriculum review	18 September 2019
9	Catholic University of Malawi	Meeting on joint teaching and research and research and curriculum review	14 October 2018
10	Ministry of Irrigation and Water Development,	Discussions on student internships and joint short course delivery	24 September 2019

	Department of Water Resources		
11	Shire River Basin Management Authority	Meeting on joint training and research	23 October 2019
12	Water Services Association of Malawi (WASAMA)	Joint Research Dissemination (Conference) as part of World Water Day, Joint Short Course for Technical personnel	7 March 2020

The above engagements discussed the following matters raised in the consultations:

- The need for student /staff industrial attachment to water industry to ensure job ready graduates and update staff know how.
- PhD level programme development to increase research production.
- Teaching collaborations with personnel from industry to ensure practical skills learning including understanding demands from industry.
- Joint Research collaborations and dissemination to maximise on limited resource and enable coordination among institutions (industry, government, CBIs)
- Joint short course delivery to upskill and update water sector personnel.

Furthermore, the University of Malawi, for instance, is addressing course shortfalls (need for practical skills training for example) raised by stakeholders and currently incorporating up to 15% of additional content. This allows for a gradual updating or modification of courses without need for immediate curriculum review. A curriculum review process under the 5-year programme cycles at the University of Malawi will incorporate the rest of the course shortfalls raised by stakeholders.

Based on the need to implement that HCD framework, the University of Malawi has successfully applied for funding to support staff and student capacity building (PhD, MSc levels, refresher courses, publications, exchange visits) under the NORHED II funding Programme.

It is envisaged that the above engagements will result in continued efforts to address shortfall in human capacity development for junior professionals and technicians in the Malawi water sector.

3.1.2. Mozambique

The national process in Mozambique resulted in the development of a Capacity Building Strategy for Junior Professional and Technician Personnel in the Water Sector led by the Ministry of Science and Technology, Higher Education and Technical Training during implementation of IPA 1. While going through cabinet processes, the strategy has been disseminated to key stakeholders. The Water Research Institute is the government entity leading in the dissemination of the strategy together with personnel from UEM. Recognising the importance of the dissemination processes, follow-up activities will be undertaken by both the Water Research Institute and UEM after the end of the project. This contributes to the sustainability and continuity of the project activities beyond the project timeline. The draft strategy influenced the design of professional courses at technical schools. The water management issues raised in the strategy were also shared with the agricultural sector coordination committee through the agricultural sector working groups and the Food, Agriculture and Natural Resource Network (FANRPAN) under its national dialogues and technical meetings. Engagement that sought collaboration in implementing the Strategy will continue with academia, Water Research Institute (IIA), Irrigation National Institute (INIR) and Ministry of Agriculture and Rural Development, and Water and Sanitation Training Centre (CEFPAS).

In accordance with IPA 1 and IPA 2, dissemination of the HCD Framework in Mozambique has reached at least 30 partners and stakeholders. The process started during the validation workshop on 14 March 2018 and has been an ongoing process and will continue after the project.

Table 5: HCD framework dissemination in Mozambique – 14 March 2018

	Name	**Category**	**Institution/ Organization**
1	Alciro Luis Nhacume	Government	National Directorate for Water Resource Management (DNGRH)
2	Suzana Saranga	Government	DNGRH
3	Cristovão Xavier	Government	DNGRH
4	António Daniel Mangue	Government	DNGRH
5	Carlos Valente Mulhovo	Government	DNGRH
6	Jose Malanço	Government	DNGRH
7	Leonard Kranendonk	Government	DNGRH
8	Carlos Mbenzane	Government	DNGRH
9	Anifa Somá	Government	DNGRH
10	Manuela Sumbane	Government	DNGRH
11	Judas Macamo	Government	DNGRH
12	José Frederico Pereira	Government	DNGRH
13	José Maria Adriano	Government	DNGRH
14	Lizete Dias	Government	DNGRH
15	Lucas Chairuca	Government	DNGRH
16	Rute Nhamucho	Government	DNGRH
17	Delário Sengo	Government	DNGRH
18	Isabel Fotine	Government	DNGRH
19	Lily Nomboro	Government	DNGRH
20	Belarmino Chivambo	Government	DNGRH
21	Rui Brito	Academia	Faculty of Agronomy and Forestry Engineering/ Department Rural Engineering
22	Mario Chilundo	Academia	Faculty of Agronomy and Forestry Engineering/ Department Rural Engineering
23	Joao Mutondo	Academia	Faculty of Agronomy and Forestry Engineering
24	Emilio Magaia	Academia	Faculty of Agronomy and Forestry Engineering/ Department Rural Engineering
25	Emilio Tostao	Academia	Faculty of Agronomy and Forestry Engineering
26	Paiva Munguambe	Government/Academia	National Institute of Irrigation and Water

	Name	Category	Institution/ Organization
27	Felicidade Massingue	Academia	Faculty of Agronomy and Forestry Engineering/ Department Rural Engineering
28	Augusto Hunguana	Academia	Mozambique Technical University (UDM)
29	Eunice Chirindza	Academia	Training Centre for Water Supply and Sanitation (MOPH/CFPAS)
30	Stefano Farolfi	Academia	International Center for Water Economics and Governance / IWEGA/ UEM
31	Dinis Juízo	Academia	Faculty of Sciences/Department of Civil Engineering
32	Atanásio Manhique	Government	Ministry of Transport and Communication/ National Institute of Meteorology
33	José Maria	Government	Águas de Moçambique (Water Supply Company)
34	Felisberto Ngovene	CEFPAS- (Water and Sanitation Training Centre)	Faculty of Arts and Social Sciences – Department of Geography
35	Joao Ribeiro	Academia	National Institute for Disaster Management /INGC

The collaboration will continue beyond the project end among academia, the Water Research Institute, the Irrigation National Institute and Ministry of Agriculture and Rural Development and the Water and Sanitation Training Centre. As indicated above, it is envisaged that dissemination activities will continue after the end of the project which will enable the involvement of as many institutions as possible. This will contribute to the continuity and sustainability of the project activity. During the just ended training course implementation, there was room to share and explain to the 41 participants the contextualization, main objectives, vision and mission and the actual stage of the Human Resource Capacity Development Strategy.

3.1.3. South Africa

Consultations in South Africa were conducted as follows: stakeholder dialogue on 21 September 2017, and stakeholder validation workshop on 22 February 2018. The process spurred conversation for the need to develop a HCD Monitoring, Evaluation and Reporting framework for Department of Water and Sanitation (DWS) to support the implementation of the National Water Sector Master plan. To this end, both UWC and CSIR have attended DWS stakeholder engagements on the Water Sector Master Plan. The idea was to explore how the Monitoring, Evaluation and Reporting (MER) Framework will align with the Master Plan. The two Sector Education and Training Authorities (SETAs) for Energy and Water (EWSETA) and Local Government (LGSETA) are keen to participate and contribute to the development of the MER framework. Collaborations between UWC and CSIR have been strengthened because of implementation of the HCD component in South Africa. The table below captures engagements on the MER framework.

In accordance with IPA 1 and IPA 2, dissemination of the Monitoring, Evaluation and Reporting (MER) Framework in South Africa has reached at least 30 partners and stakeholders since there were more than 51 attendees who already attended the validation meeting. The process

started during the validation workshop on 22 February 2018 and has been an ongoing process and will continue after the project, as indicated in Table 6 below.

Table 6: Monitoring, Evaluation and Reporting framework engagements in South Africa

	Forum/platform	Comment	Date
1	National Validation Meeting on Junior Professional and Technician-level Capacity	Held in Pretoria	22 February 2018
2	Department of Water and Sanitation National Consultative Workshop	The need for the development of the MER framework was tabled for inclusion in the National Water and Sanitation Sector Masterplan (within the framework of IPA 1)	01 February 2018
3	National Water and Sanitation Sector Leadership Group (WSSLG) Task Team for Capacity Building and Skills Development Meeting	The proposal for the MER framework was presented as part of reporting on Chapter 15 (Water Sector Capacity and Skills Development) of the National Water Resources Strategy (within the framework of IPA 1)	23 May 2018
4	9th SADC Multistakeholder WEFE Nexus Dialogue	The MER framework formulation formed part of a presentation titled "The 4th Industrial Revolution and its Implications for Job Creation"	26-27 March 2019
5	UNESCO Workshop on Launching of the Water Management Curriculum for Africa	The MER framework preparation presented during the workshop	28-29 November 2019
6	National Water and Sanitation Sector Leadership Group (WSSLG) Task Team for Capacity Building and Skills Development Meeting	Update report on ongoing consultation on the development of the MER framework	28 February 2020

As at the end of IPA 2 in November 2020, discussions regarding the development of the MER Framework are ongoing and for the most part led by the Department of Water and Sanitation as the sector leader. This contributes to the sustainability and continuity of the project activities beyond the project timeline.

3.1.4. Zambia

The process contributed towards the formulation of a national plan on occupation qualifications and technical skills training for the water sector. Following the consultations, the University of Zambia (UNZA) has been engaging with various stakeholders as summarised in the table below. In accordance with IPA 1 and IPA 2, dissemination of the HCD Framework in Zambia has reached at least 30 partners and stakeholders, since 15 stakeholders attended the validation workshop held the 31st of January 2018. This was followed by consultations (Table 7), which reached 23 stakeholders and organisations:

1. Assistant Director, Department of Water Resources Development
2. Acting Director General, Water Resources Management Authority
3. Acting Director, WRM & I, Water Resources Management Authority
4. Senior Hydroinformatics Officer, Water Resources Management Authority
5. Water Resources Management Specialist, ZWRDP
6. Human Resources and Administration Manager, WARMA
7. Assistant Coordinator, UNZA – IWRM Centre
8. NAWSCO
9. Lusaka Water and Sewerage Company
10. Kafubu Water and Sewerage Company
11. Lukanga Water and Sewerage Company
12. Chambeshi Water and Sewerage Company
13. Mulonga Water and Sewerage Company
14. Nkana Water and Sewerage Company
15. National Rural Water Supply and Sanitation Program coordinator
16. Academic Institution (UNZA Engineering Head of Department Civil and Environmental Engineering)
17. Natural Resources Development College Water (NRDC Engineering Department)
18. Copperbelt University
19. Mulungushi University
20. Department of Water Resources Development
21. Ministry of Local Government
22. WaterAid Zambia
23. Water Resources Consulting (WRC) Limited

Table 7: HCD framework dissemination in Zambia

	Stakeholder	**Comment**	**Date**
1	Ministry of Water Development, Sanitation and Environmental Protection, Planning Department	Meeting was to discuss the modalities for the framework forward Discussion on the framework were included on the agenda of the Technical Committee on Water Resources Management	Meeting scheduled for March 2020 but did not take place as a result of the COVID-19 pandemic
2	GIZ Federal Institute for Geosciences and Natural Resources (BGR) Water Resources Management Authority (WARMA)	Meetings on the development of tailor-made courses for drillers based on recommendations from the framework. GIZ/BGR agreed to finance capacity building for drillers	24 April 2020 2 October 2020

Discussions during the meetings with the GIZ, BGR and WARMA, focused on:

a) Conducting a comprehensive/rapid needs assessment for the anticipated training
b) Developing/updating documents using the Technical and Vocational Education and Training Authority (TEVETA) format and seek guidance and approval from TEVETA. This includes:

- Selection of the training institutions to offer courses.
- Job profiles describing the roles and tasks to be performed upon successful completion of training.
- Training equipment and tools required.
- Curriculum/Syllabus which gives details of training units and topics to be covered including the learning outcomes and modes of assessments.
- Accreditation of training institutions to conduct short courses.

c) Implementation of Trainings of Trainers (ToT)

The meeting agreed that the drillers course would be developed at two levels: (i) skills and (ii) supervisors' course. GIZ/BGR will constitute a technical committee that will provide guidance on the depth of coverage and scope of material. The process has been delayed as well because of COVID-19 but will resume in early 2021 with support from GIZ/BGR and WARMA. The support from GIZ/BGR and WARMA will contribute to the continuity and sustainability of the project activity.

3.2. Training courses

The development of training course followed from Phase I of the project wherein situational analysis were conducted at the national level in Botswana, Malawi, Mozambique, South Africa and Zambia. These were followed by stakeholder dialogues to prioritise capacity needs and validation workshops to validate outputs from the national process. As part of IPA 2, CoEs were to:

Design and implement new courses or course curricula material addressing junior and senior professional and technician level capacity for a minimum of top two priorities (minimum of 4 courses) per Pilot country.

- Based on the implementation framework, design a minimum of two courses or curricula adaptation and/or modules for vocational training for junior and senior technicians, including education material. Courses can be new full courses, modular, or integrated into existing programs
- Design a minimum of two courses or curricula adaptation and/or modules for master's courses for junior and senior professionals, including education material. Courses can be new full courses, modular, or integrated into existing programs
- Course quality checks, including the analysis of the structure, content and training material

Implementation of the courses for junior and senior professionals and technicians

- Purchase necessary equipment, software and consumables (to be defined by each Pilot Country) for computational numerical modelling for:
  - Software and tools for computational numerical modelling for Water/Climate labs
  - Tools and equipment for water quality laboratories
- Technical support to the first-year implementation of a minimum of 4 courses for junior and senior professionals at master level and technicians for technical level training

3.2.1. Implementation of training courses

Implementation of training courses was originally planned for Botswana, Malawi, Mozambique and Zambia as tangible programmes from the national processes in Phase I. For South Africa,

courses for implementation for Phase II were identified from a desk-study and consultations during the scoping studies under IPA 1. It's HCD component fell within the fifth implementing area of the National Water Resources Strategy (II): water sector skills and capacity. This addresses 7 strategic themes as follows: 1) water resources planning, development and infrastructure management; 2) water resource protection; 3) equitable water resources; 4) water conservation and water demand management; 5) managing water resources for climate change; 6) regulation of the water sector; and 7) international and transboundary water resource management. Training courses identified for face-to-face delivery are summarised in Table 1. The detailed course outlines and contents for all five countries, including South Africa are provided in Annex 1.

Table 8: Prioritised pilot courses

Country	Professional courses	Technician courses
Botswana	1. Advanced Hydrology 2. Water Resources Management	1. Applied and Field Hydrology for Practitioners 2. Principles of Hydrology for Technicians and Artisans
Malawi	1. Water Quality Modelling 2. Hydrological modelling	1. Water Supply 2. Water and Sanitation Systems 3. Certificate programme for Water Technicians 4. Apprentice Diploma Programme for Water Technicians
Mozambique	1. Management and Maintenance of Networks And Water Loss 2. Community Education	1. Environmental Impact Assessment 2. Water Quality Assessment
South Africa	1. Environmental Assessment and Management - IWRM and the Workplace 2. Introduction to groundwater hydrology 3. Water Demand Management & Water Security	
Zambia	1. Water Resources Monitoring 2. Water Environmental Quality Modelling	1. Hydrogeology and Drilling Supervision Training 2. Field Hydrogeology

However, plans were affected by the COVID-19 pandemic which necessitated, where possible, a shift towards online, blended and distance learning. An e-readiness assessment was conducted to understand and evaluate the current level of capacity of CoEs to implement distance and online courses for professional and technician level personnel during the remainder of the project. A questionnaire was administered to understand existing staff and institutional capabilities to deliver distance and online learning as well as access to hardware, software and technical support for the delivery. Overall, the assessment indicated that:

- Respondents from CoEs have had some training and experience in offering online learning.
- Although with varying levels of readiness, institutions have the technical support necessary to roll out online learning.

- Respondents are conversant with online learning platforms such as Zoom, MS Teams and Google Meet.
- Further training was required to improve online and distance learning delivery.
- To a large extent, access to internet data was a problem for students while some CoEs still have to developing online learning platforms and improve on ICT infrastructure for online learning.

Following the e-readiness assessment and given project timelines, the University of Botswana opted out of implementing training courses. The Council for Scientific and Industrial Research and the University of the Western Cape opted to participate in the course implementation. While at the end national processes in Phase 1 stakeholders agreed that development of a monitoring, evaluation and reporting (MER) framework was a priority for South Africa, courses for implementation this Phase II were identified from a desk-study and consultations during the scoping studies under IPA 1. For South Africa, the HCD component fell within the fifth implementing area of the National Water Resources Strategy (II): water sector skills and capacity. This addresses 7 strategic themes as follows: 1) water resources planning, development and infrastructure management; 2) water resource protection; 3) equitable water resources; 4) water conservation and water demand management; 5) managing water resources for climate change; 6) regulation of the water sector; and 7) international and transboundary water resource management. The courses offered by the UWC and CSIR also complemented the Framework Programme for Research, Education & Training in the Water Sector (FETWater III) initiative implemented by the South African Department of Water and Sanitation through the Water Research Commission. The courses implemented by UWC and CSIR therefore align with the themes identified in the second National Water Resources Strategy as well as creates linkages between academic training and occupationally directed training as motivated for by the FETWater III.

Altogether, eight courses out of 20 planned courses were developed under Phase II. Seven (7) courses were implemented by the Universities of Malawi, Eduardo Mondlane (Mozambique), the Western Cape and the Council for Scientific and Industrial Research (both in South Africa). Of the eight courses prepared, 7 were reviewed and updated for presentation while 1 course was developed anew by the University of Zambia but not offered as a result of time limitations of the project. Table 9 below summarises the courses offered as well as information on the number of courses and level of training.

Table 9: Summary of courses implemented

CoE name	**University of Malawi**	**Universidade Eduardo Mondlane**	**Council for Scientific and Industrial Research**	**University of the Western Cape**	**University of Zambia**
Course names	C1 - Water and Sanitation Systems C2 - Hydrological Modelling & Water Quality Modelling Combined Course	C1 - Management and Maintenance of Networks and Water Loss C2 - Environmental Impact Assessment	Environmental Assessment and Management-IWRM and the Workplace (course offered	C1 - Water Demand Management & Water Security C2 - Introduction to groundwater hydrology	Hydrogeology and Drilling Supervision Training (time invested in course development.

			in collaboration with UWC)		Course not offered)
Course level (Bachelors, Masters, TVET)	C1 – Masters C2 – Masters	C1 - professional course C2 - TVET	Honours	C1 - Postgraduate Diploma C2 - Bachelors	TVET
Course dates	21 September - 2 October	C1: 7– 13 October C2: 8 – 14 October	31 August – 04 September	C1: 17 Aug -25 September C2: 27 July – 4 September	
Mode of instruction	Face to face	Face to face	Online	Online	
No. of learners	C1: 10 - 3F, 7M C2: 6 – 3F, 3M	C1: 20 – 9F, 11M C2: 21 – 10F, 11M	20 – 13F, 7M	C1: 5 – 3F, 2M C2: 99 – 61F, 36M, 2 - NR	
HR needs	Teaching assistants and technicians	Assistants and instructors	Instructor	Assistant & technicians	
Materials	• 1 Team Licence MODFLOW Team Basic • Water quality testing kits • Water quality lab chemicals	• Course materials • Alcohol spray and masks	None	None	

Further information on the courses, in the context on training priorities identified by stakeholders, is presented below.

3.2.1.1 University of Malawi

The sector still faces some challenges apart from the recently updated Act and any other instruments that are available. Capacity building is one of the areas that have some key constraints and challenges. These challenges and constraints have direct impact on the junior profession and technical capacities in the sector.

Two courses, namely, Hydrological Modelling & Water Quality Modelling Combined Course and Water and Sanitation Systems were offered by the University of Malawi from 21 September – 2 October 2020. These courses are part of the HCD priorities trainings identified during Phase I. Prioritised trainings are captured in Table 10 below. While the prioritized trainings indicated in Table 8 listed Hydrological Modelling; Water Quality Modelling, Water Supply; and Water and Sanitation Technology, priorities, a decision was taken to combine the two courses on Water Quality Modelling and Hydrological Modelling. Courses on Water and Sanitation Systems was offered instead at the Junior professional level instead of the planned technician level.

Table 10: Prioritised trainings - Malawi

Level	Prioritised trainings	Project intervention	Course delivered
Junior professional level	Hydrological Modelling & Water Quality Modelling Combined Course	Existing course – reviewed and updated	✔
	Water and Sanitation Systems	Existing course – reviewed and updated	✔
Technician level	Certificate programme for Water Technicians		
	Water Supply		
	Apprentice Diploma Programme for Water Technicians		

Both courses were at the masters level and offered to existing enrolled students at the University of Malawi. Courses were delivered face to face. The course outlines and teaching materials are contained in a folder (Teaching Material - UNIMA) accompanying this report.

For the courses implemented, Hydrological Modelling & Water Quality Modelling, detailed contents were submitted, along with a detailed course calendar and PPTs/full course materials, as well as participants' evaluation/feedback. For the course Water and Sanitation Systems, detailed contents and PPTs/full course materials were provided, as well as participants' evaluation/feedback. According to IPA 2 Malawi has therefore met all requirements.

3.2.1.2 Universidade Eduardo Mondlane

Several studies indicate that water resources are becoming increasingly scarce in the country and represent a direct impact on improving the quality of life and on the production process, whether in urban or rural areas. In this context, there is an urgent need to implement measures for the efficient management of water resources, which requires the existence of qualified professionals in the different technical areas related to water.

Two courses, namely: Maintenance of Networks and Losses and Environmental Impact Assessment, were offered by the Universidade Eduardo Mondlane from 7 – 13 October 2020. Courses delivered were part of courses prioritised by stakeholders during Phase 1. Prioritised courses are captured below in Table 11.

Table 11: Prioritised trainings - Mozambique

Level	Priority courses	Project intervention	Courses delivered
Junior professional level	Management and Maintenance of Networks and Water Loss	Existing course – reviewed and updated	✔

	Community education		
	Water Economics and Governance		
	Integrated Water Resources Management		
Technician level	Environmental Impact Assessment	Existing course – reviewed and updated	✔
	Water Quality Management		
	Design and Assembly of Different Water Supply Systems		

The Management and Maintenance of Networks and Water Loss course was offered as a short course (professional training) while the Environmental Impact Assessment course was targeted at the technician level. Both courses were offered using a face-to-face delivery. The course outlines and teaching materials are contained in a folder (Teaching Material - UEM) accompanying this report.

For the courses implemented, Environmental Impact Assessment, detailed contents, PPTs, full course materials and participant evaluation/feedback were submitted. Only a full course calendar was therefore not submitted. The provision of a full course calendar was however not required under the agreement. For the course Management and Maintenance of Networks and Water Loss, the same applies. According to IPA 1 and IPA 2, Universidade Eduardo Mondlane has met all requirements.

3.2.1.3 Council for Scientific and Industrial Research

A scoping study for South Africa identified several challenges, such as a lack of coordinated mechanism for planning, delivery and quality assurance; and the availability of different education/skills development providers within the sector at different levels. Clear challenges were the identified for skills and capacity development in the water sector which means that interventionists know the challenges. With such knowledge, the new challenge is how to prioritise, who should prioritise to address the identified challenge more systematic and on a sustainable basis so the chain of intervention is sustained.

As mentioned above, while at the end of the national processes in Phase I stakeholders agreed that development of a monitoring, evaluation and reporting (MER) framework was a priority for South Africa, courses for implementation this Phase II were identified from a desk-study and consultations during the scoping studies under IPA 1. For South Africa, the HCD component fell within the fifth implementing area of the National Water Resources Strategy. The Council for Scientific and Industrial Research (CSIR) collaborated with the University of the Western Cape (UWC) to deliver a course entitled Environmental Assessment and Management. The course is a postgraduate level at the Honours level. The CSIR component of this one semester course concentrated on translating academic knowledge to the workplace environment hence practical and skills components to the course. This component was

prepared and offered by CSIR and ran from 31 August - 04 September 2020. The course was delivered through online learning using Ikamva (a UWC learning portal) and Google Meet.

The course outline and teaching materials are contained in a folder (Teaching Material - CSIR Component - Environmental Assessment and Management: Integrated Water Resources Management (IWRM) and the Workplace) accompanying this report. For this course, the CSIR only submitted PPTs/full course materials. Detailed contents. The provision of a course calendar was not needed under the agreement. As this course was implemented in collaboration with UWC, participant evaluation/feedback was also integrated with that of UWC. According to IPA 2, CSIR has met all requirements.

Table 12: Prioritised trainings – South Africa – CSIR

Level	Planned trainings	Project intervention	Course delivered
Junior professional level	Environmental Assessment and Management - IWRM and the Workplace	In collaboration with UWC	✔

3.2.1.4 University of the Western Cape

Two courses, namely: Water Demand Management & Water Security (Water, human security and Development) and Introduction to Groundwater Hydrology, were offered by the University of the Western Cape from 17 August - 25 September 2020 and 27 July – 4 September 2020 respectively. Both courses were offered online using both synchronous (4 hours daily) – via Ikamva and Google Meet and asynchronous (4 hours daily) methods. The course outlines and teaching materials is contained in a folder (Teaching Material - UWC) accompanying this report. For both courses Introduction to groundwater hydrology; Water Demand Management & Water Security, PPTs/full course materials and participant evaluation/feedback were provided. According to IPA 2, UWC has met all requirements.

Table 13: Prioritised trainings – South Africa – UWC

Level	Planned trainings	Project intervention	Courses delivered
Junior professional level	Introduction to groundwater hydrology		✔
	Water Demand Management & Water Security		✔

3.2.1.5 University of Zambia

The scoping study revealed that in order to bridge the huge skills gap the Government should forge partnerships with other training institutions in the country. Implementation of the Government policies of sponsorship, part time training and development, counterpart training, integrating learning with work, etc. will also contribute to meeting water sector skills and knowledge requirements.

The University of Zambia developed a course on Hydrogeology and Drilling Supervision Training for implementation as shown in table 14.

Table 14: Prioritised trainings - Zambia

Level	Prioritised trainings	Project intervention	Trainings developed
Junior professional level	Water Resources Monitoring		
	Environmental Quality Modelling		
Technician level	Field Hydrogeology		
	Hydrogeology and Drilling Supervision Training	Developed anew	✔

However, due to the COVID-19 pandemic, the course could not be offered within the project timelines but will be offered in 2021 with support from GIZ/BGR and WARMA. Preparatory work for the course included:

- Development of course material
- Engagement with the Water Management Authority and the Drillers Association of Zambia to collaborate on the course
- Discussions with the Department of Planning with the Ministry of Water Development Sanitation and Environmental Protection
- Agreement with the Water Management Authority for recognition and certification of the course
- Agreement with the Natural Resources Development College to co-deliver the course.

Course preparation and development involved the costs listed in Table 15. Logistics to help organize the online courses such as engagements with above stakeholders for certification, collaboration and co-delivery; a lecturer engaged to help develop/prepare the course. Communications mainly involved the advertisement of the online course, but also engagement with the above stakeholders. The same applies to coordination costs. As stated above, due to COVID-19 this course could not be offered within the project timeline. These costs therefore only went towards preparation and development.

Table 15: Costs incurred for course preparation and development

Role	Course/module	Phase	Unit	Total time (Days)	Unit cost (USD)	Total cost (USD)
Human Resources	Hydrogeology and Drilling Supervision training	Logistics		1	250	**250**
		Lecturer (preparation time)		4	350	**1400**
		Communications (advertisements)		1	250	**250**
		Coordination		1,4	250	**350**
Total						**2 250**

The course outline and teaching materials are contained in a folder (Teaching Material - UNZA) accompanying the report. For all four prioritised courses, detailed contents were provided. For Hydrogeology and Drilling Supervision Training, detailed course calendar and PPTs/full course materials were also provided. No participant feedback/evaluation was provided for any of the four courses. This was however not necessary since no courses were implemented. According to IPA 2, Zambia has met all requirements, except for implementation of courses.

4 Purchase of materials and consumables

Of the four CoEs that delivered training courses, two universities purchased materials as part of course delivery namely University of Malawi and Universidade Eduardo Mondlane. The Council for Scientific and Industrial Research and the University of the Western Cape opted not to purchase equipment to aid in course delivery as the latter's labs were adequately resourced for online practical course delivery. Table 16 below presents what was purchased.

Table 16: Materials and consumables purchased for course implementation

Name of CoE	Materials and consumables for course implementation	Course name
University of Malawi	1 Team Licence MODFLOW Team Basic Water quality testing kits Water quality lab chemicals	Hydrological Modelling & Water Quality Modelling Combined Course
Universidade Eduardo Mondlane	Print outs of course materials Sanitiser and face masks	Management and Maintenance of Networks and Water Loss Environmental Impact Assessment

As seen in Table 16, while UNIMA purchased software and lab equipment to aid in the delivery of the Hydrological Modelling & Water Quality Modelling Combined Course, the UEM procured printouts of course materials and protective equipment for coronavirus prevention for both the Management and Maintenance of Networks and Water Loss and the Environmental Impact Assessment.

5 SANWATCE exchange programme

The task as outlined in IPA 2 for the SANWATCE Secretariat was to:

> Manage the regional staff and or Human Resources and student exchanges (improving regional networking) within and between Networks
>
> - Defining a Regional Student Exchange Programme for PhD and Master's students (including collaboration topics and student selection process) and establishing the exchange agreement between the African universities
> - Supporting the COEs in managing the student and HR exchanges
> - Supporting the Exchange scholarships (at least 10 exchange scholarship)

The SANWATCE exchange programme was aimed at strengthening the Network through the mobility of both staff and students. The plan was to facilitate at least 11 staff exchanges and 5 student exchanges as follows:

i. **Staff exchange**

- Staff exchange to participate in facilitating professional level courses under the ACEWater2 HCD component piloting
- Staff exchange to participate in facilitating the technician level courses as part of the ACEWater2 HCD component piloting
- Staff exchange programme to work on joint research development and or the use of specialised equipment
- Duration: minimum 3 weeks
- Number of staff exchanges: 11 (at least one per CoE)

ii. **Student exchange**

- Full time students to attend specialised training or access to specialised equipment or co-supervision
- Duration: minimum of 1month and up to 3 months

Nine nominations for the SANWATCE Exchange Programme had been received as of March 2020. Names of nominees are shown in Table 17 below with details of their home and visiting institutions.

Table 17: SANWATCE Exchange Programme nominees

Home CoE	Name of nominee	Visiting CoE
UB	Prof Piet Kenabatho	SU
UNIMA	Mr Peter Chimtali	UWC
UNIMA	Mr Oscar Kambombe	UWC
UWC	Ms Paula Finini	CSIR
UNZA	Dr Joel Kabika	UWC
UNZA	Mr Mulema Mataa	UWC

However, the exchange programme was cancelled due to the COVID-19 pandemic. At cancellation, one (1) student from the University of Zambia had taken up the opportunity and was at the University of the Western Cape. The student spent a total of 6 weeks at UWC and left prematurely as a result of the then impending national COVID-19 lockdown. The student participated in courses and had access to laboratories at UWC for analysis of water quality samples as part of his Masters training. The student was supervised by faculty at UWC. The exchange programme plan and related documents including the student report is contained in Annex 1.

6 Project Monitoring and Evaluation

The Monitoring and Evaluation process was developed following a consultation process with the UNESCO Project Coordinators, Impact expert including a document review, presentation and feedback from CoEs in WANWATCE and CEANWATCE regions. The Monitoring and Evaluation tool was designed using a Main Frame which included one general and four specific project objectives, indicators per specific objective and activities aligned to each indicator.

The objectives were agreed in consultation with the UNESCO.

Global Objective

Implement the Human Capacity Development Programme in up to four countries per region in collaboration with relevant institutions and fostering sustainable capacity development approach (per country) — each one of the activities will be implemented in each of the pilot countries.

Specific Objectives

i. Dissemination of the strategy to stakeholders, donors, and training institutions at national level

ii. The Pilot courses/modules and laboratories are supplied with the relevant Software, Tools and Consumables in a timely manner

iii. A strategy for Regional HR and student exchanges is implemented to improve regional networking

iv. A quality review of the implemented courses/modules is undertaken including student and course interlocutors' feedback with the results analysed and course adjustments implemented, where appropriate.

The following figures are only applicable to SANWATCE, except for Figure 2.

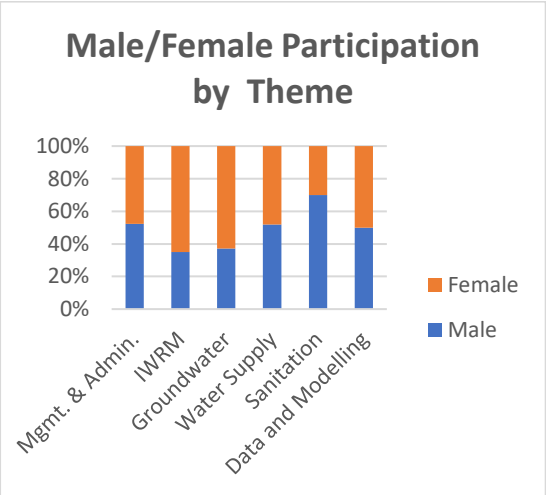


Figure 1: Gender breakdown by theme

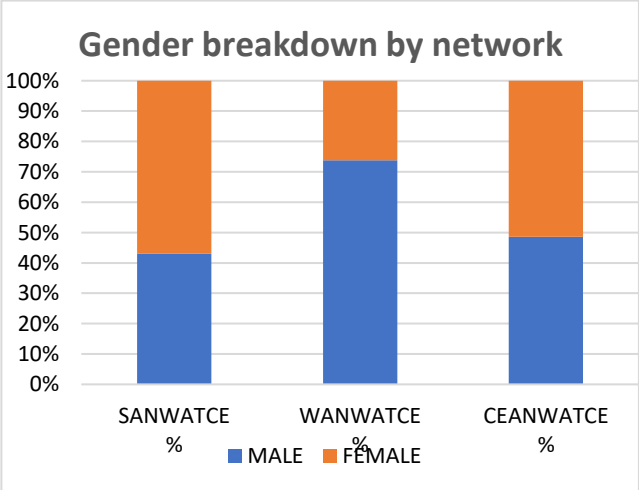
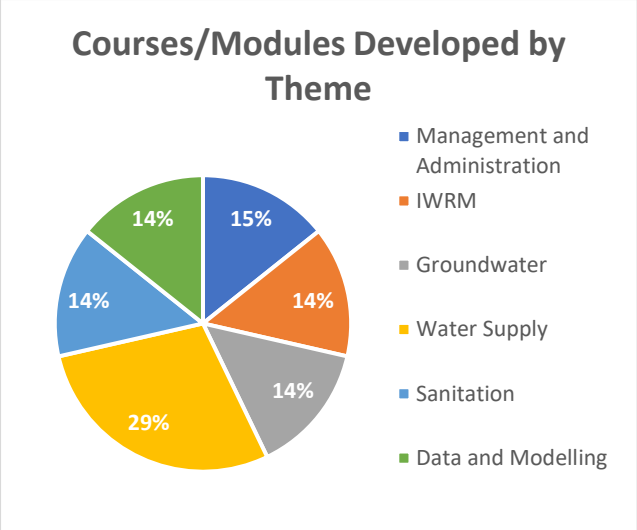


Figure 2: Gender breakdown by region

Gender breakdown by theme is fairly evenly distributed. With more than 60%, courses on IWRM and Groundwater however had notably more female attendance, while Sanitation courses had more male attendance. Figure 2 indicates that SANWATCE, at 57%, had notably more female attendance than WANWATCE and CEANWATCE.



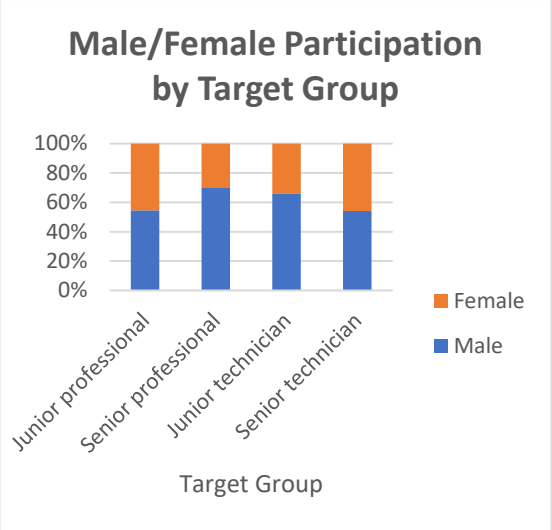
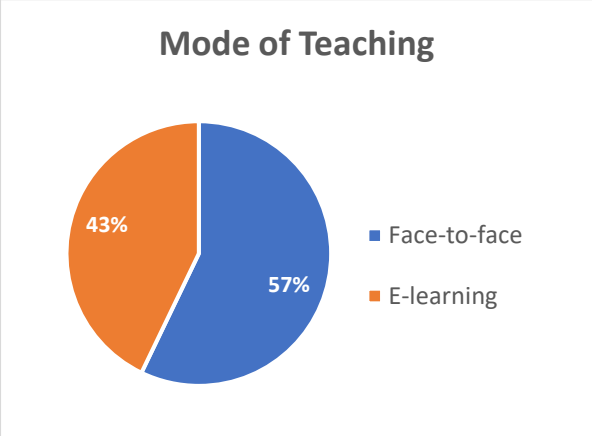


Figure 3: Implementation by theme

Figure 4: Gender participation by target group

Figure 3 shows that implemented course had mostly a water supply theme. Across SANWATCE, 80% of courses were aimed at junior professionals, 20% at junior technicians, while none were at senior levels of professionals and technicians. In terms of gender, Figure 4 shows that courses for junior professionals were mostly attended by females, while for junior technicians, the percentage breakdown is more even.



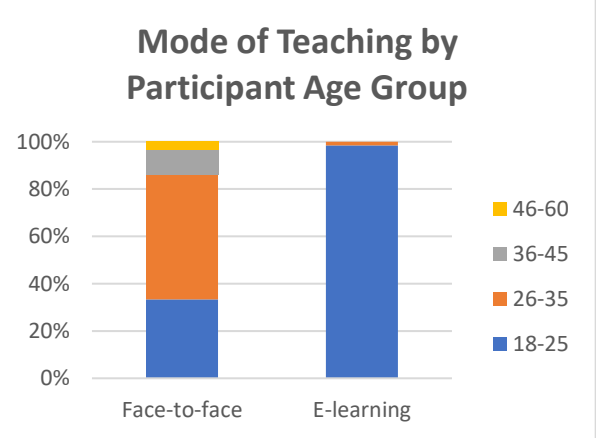


Figure 5: More of teaching

Figure 6: Mode of teaching by age groups

Figure 5 indicates the percentage breakdown between face-to-face and online e-learning courses. It also shows that no blended courses were implemented. Two thirds of online learning platforms used were Zoom, while the other third was Google Meet. Figure 6 indicated that the vast majority of e-learning courses were attended by participants aged 18-25, while face-to-face courses were mostly attended by 26-35 the population group.

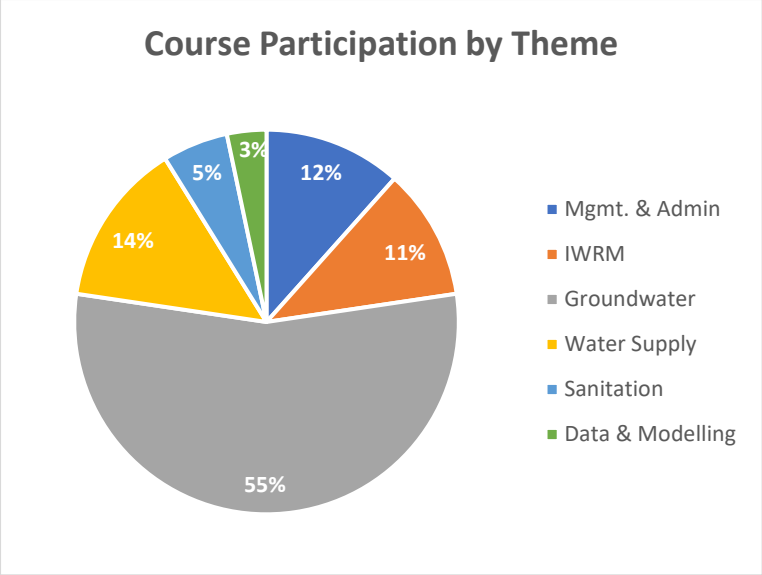
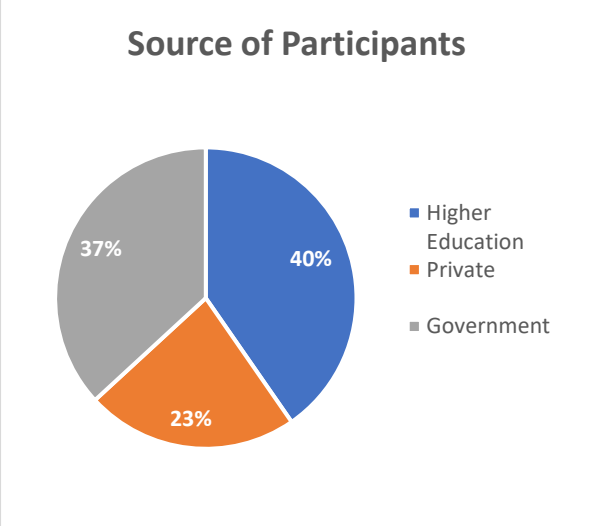


Figure 7: Participants by theme

The majority of participation was for groundwater-themed courses. This also corresponds with Figure 3 which showed that most courses implemented were also by this theme.



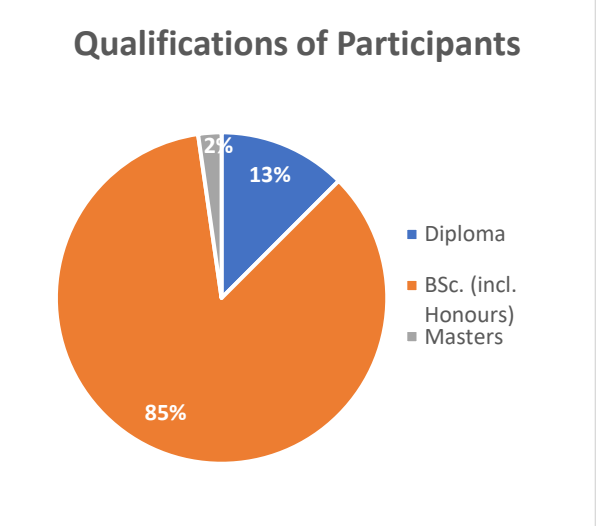


Figure 8: Source/background of participants Figure 9: Qualification of participants

Participants from higher education and government institutions were almost evenly distributed, while participation from private institutions was lower and no participants from TVET institutions (Figure 8). Note that numbers for UWC and CSIR were not available for this indicator. The vast majority of participants had at least a BSc. (including Honours) qualification, while no participants had a just a high school qualification (Figure 9).

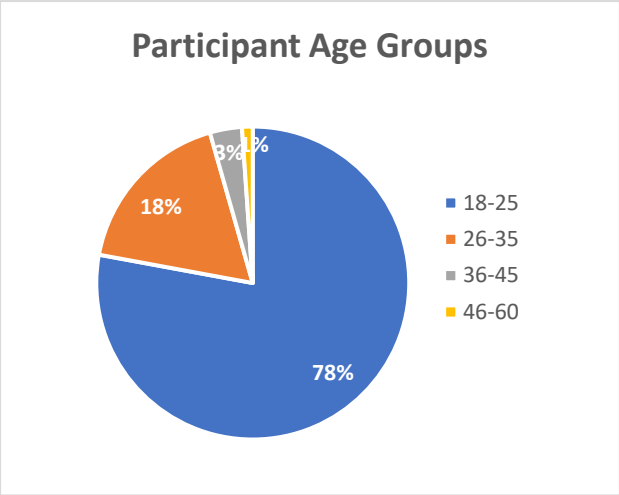


Figure 10: Age groups of participants

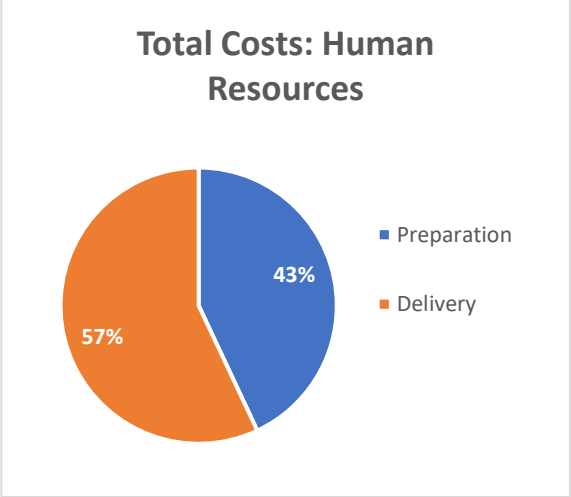


Figure 11: Costs on human resources

The vast majority of participants were aged 18-25 (Figure 10). In terms of costs incurred for course preparation and implementation, as also described in Table 15, almost 100% of costs for goods and supplies were towards course delivery, while costs for human resources (Figure 11) were much more evenly divided between course preparation (43%) and delivery (57%).

The following recommendations were made from the M&E activity. The recommendations are aimed at improving any future activities related to the ACEWATER II HCD Pilot Project.

- It is recommended that an analysis of the course thematic areas developed and implemented versus the gap needs assessment which was undertaken by each CoE earlier in the project should be undertaken. This would provide a useful overview to understand if the project deviated from its original intentions or fulfilled the expectations of the different stakeholders at a country, regional and agency level.
- To ensure that Monitoring and Evaluation is included and implemented from the start of the project. This will also allow for real-time analysis which will assist the decision makers to adjust the project in a proactive timely manner.
- It would be recommended to ensure a closer alignment of the M&E Tool with the pilot course design to develop a good understanding of the M&E reporting requirements and the timeframe by which reporting should be completed.
- It would be advisable to create a central reporting environment which each CoE can access and complete the M&E information. This does not need to be a complicated database, but a shared document stored centrally where follow up and version control is easy to manage.
- It would be advisable to request the CoE to conduct a further quality review of the pilot courses/modules six months to 12 months after their completion to assess the impact of the trainings. This would help guide the development and implementation of the any further phases of the project.

Table 18: Synthesis of M&E

COURSE / MODULE TITLE	LOCATION	Status	TARGET GROUP	MODE OF TEACHING	E-LEARNING PLATFORM	GENDER OF PARTICIPANT		AGE GROUPS				NUMBER OF Ps.
						M	F	18-25	26-35	36-45	46-60	
Advance Hydrology	Botswana	not implemented	Junior Professional			-	-	-	-	-	-	
Water Resources Management	Botswana	not implemented	Junior Professional			-	-	-	-	-	-	
Applied and Field Hydrology for Practitioners	Botswana	not implemented	Technician			-	-	-	-	-	-	
Principles of Hydrology for Technicians and Artisans	Botswana	not implemented	Technician			-	-	-	-	-	-	
Hydrological Modelling & Water Quality Modelling Combined Course	Malawi	implemented	Junior Professional	FACE 2 FACE	N/A	3	3	6	-	-	-	6
Water and Sanitation Systems	Malawi	implemented	Junior Professional	FACE 2 FACE	N/A	7	3	3	7	-	-	10
Water Supply	Malawi	not implemented	Technician									
Certificate programme for Water Technicians	Malawi	not implemented	Technician			-	-	-	-	-	-	
Apprentice Diploma Programme for Water Technicians	Malawi	not implemented	Technician			-	-	-	-	-	-	
Community education	Mozambique	not implemented	Junior Professional			-	-	-	-	-	-	
Water quality assessment	Mozambique	not implemented	Technician			-	-	-	-	-	-	
Management and Maintenance of Networks and Water Loss	Mozambique	implemented	Junior Professional	FACE 2 FACE	N/A	11	9	9	7	2	2	20
Environmental Impact Assessment	Mozambique	implemented	Technician	FACE 2 FACE	N/A	11	10	1	18	4	0	21
Environmental Assessment and Management - IWRM and the Workplace	South Africa	implemented	Junior Professional	E-LEARNING	Google Meet	7	13	20				20
Introduction to groundwater hydrology	South Africa	implemented	Junior Professional	E-LEARNING	ZOOM	36	61	99	0			99
Water Demand Management & Water Security	South Africa	implemented	Junior Professional	E-LEARNING	ZOOM	2	3	3	2			5
Water Resources Monitoring	Zambia	not implemented	Junior Professional									
Water Environmental Quality Modelling	Zambia	not implemented	Junior Professional									
Field Hydrogeology	Zambia	not implemented	Technician									
Hydrogeology and Drilling Supervision Training	Zambia	not implemented	Senior Technician	BLENDED	ZOOM							

Table 19: Synthesis course checklist

COURSE / MODULE TITLE	LOCATION	Status	TARGET GROUP	Detailed contents provided	Detailed course calendar	Full Course Materials/ PPTs	Participants Evaluation & Feedback
Advance Hydrology	Botswana	not implemented	Junior Professional	✓			
Water Resources Management	Botswana	not implemented	Junior Professional	✓			
Applied and Field Hydrology for Practitioners	Botswana	not implemented	Technician	✓			
Principles of Hydrology for Technicians and Artisans	Botswana	not implemented	Technician	✓			
Hydrological Modelling & Water Quality Modelling Combined Course	Malawi	implemented	Junior Professional	✓	✓	✓	✓
Water and Sanitation Systems	Malawi	implemented	Junior Professional	✓		✓	✓
Water Supply	Malawi	not implemented	Technician	✓			
Certificate programme for Water Technicians	Malawi	not implemented	Technician				
Apprentice Diploma Programme for Water Technicians	Malawi	not implemented	Technician				
Water quality assessment	Mozambique	not implemented	Technician	✓			
Community education	Mozambique	not implemented	Junior Professional	✓			
Environmental Impact Assessment	Mozambique	implemented	Technician	✓		✓	✓
Management and Maintenance of Networks and Water Loss	Mozambique	implemented	Junior Professional	✓		✓	✓
Environmental Assessment and Management - IWRM and the Workplace	South Africa	implemented	Junior Professional	✓		✓	
Introduction to groundwater hydrology	South Africa	implemented	Junior Professional	✓		✓	✓
Water Demand Management & Water Security	South Africa	implemented	Junior Professional	✓		✓	✓
Water Resources Monitoring	Zambia	not implemented	Junior Professional	✓			
Water Environmental Quality Modelling	Zambia	not implemented	Junior Professional	✓			
Field Hydrogeology	Zambia	not implemented	Technician	✓			
Hydrogeology and Drilling Supervision Training	Zambia	not implemented	Senior Technician	✓	✓	✓	

The M&E report accompanies this report as a separate document.

7 Course evaluation and feedback

A review of the contribution to impact on the following was conducted:

- Knowledge
- Policy/Institutional
- Social
- Economy
- Ecology

When reviewing the impact on the above five areas, only 29 participants across CSIR, UWC in South Africa, UEM in Mozambique and UNIMA in Malawi provided feedback. As stated previously, CSIR collaborated with UWC, including participant feedback/evaluation. UNIMA provided course feedback in a qualitative format, while aligning closely with the quantitative figures below. At the higher level, considering all three regions, SANWATCE, WANWATCE and CEANWATCE, feedback was overwhelmingly positive (108 responses). 25 participants were students, 75 employed and four unemployed. For SANWATCE alone, 21 were students and 8 formally employed. Feedback from SANWATCE participants was similarly positive. Below are examples of feedback received which speaks to the contribution to impact.

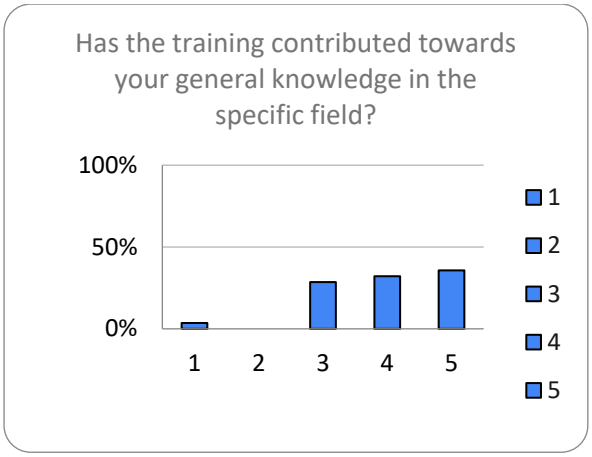


Figure 12: Contribution to knowledge of field

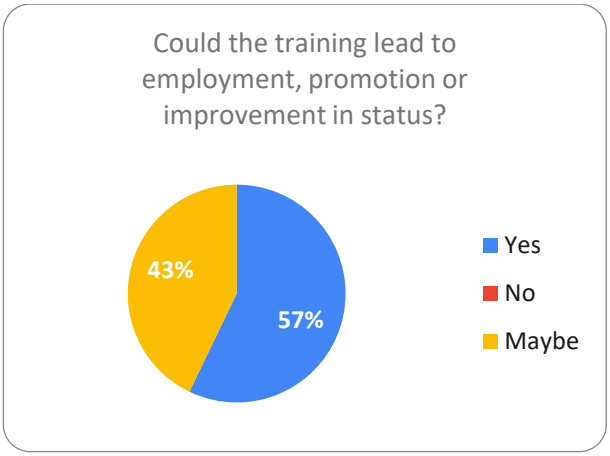


Figure 13: Employment, promotion

In terms of the extent to which the training has contributed to their general knowledge in the specific field (Figure 12), responses were relatively evenly distributed between 3, 4 and 5 (5 – fully agree). Figure 13 shows 57% felt that the training could lead to employment, promotion or improvements of status and 43% maybe.

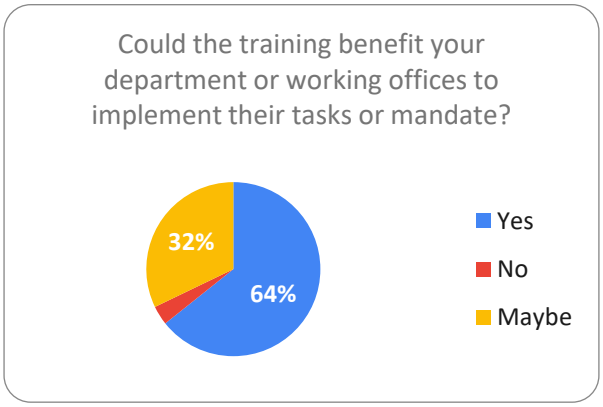


Figure 14: Benefit to department/work

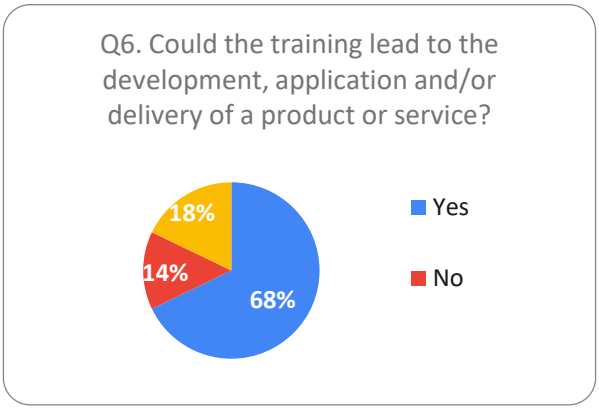


Figure 15: Development/delivery of service

64% of SANWATCE partners indicated that the training could benefit their department or working offices to implement tasks or mandate (Figure 14). A majority of 68% of participants said that the training could lead to development, application and/or delivery of a product or services.

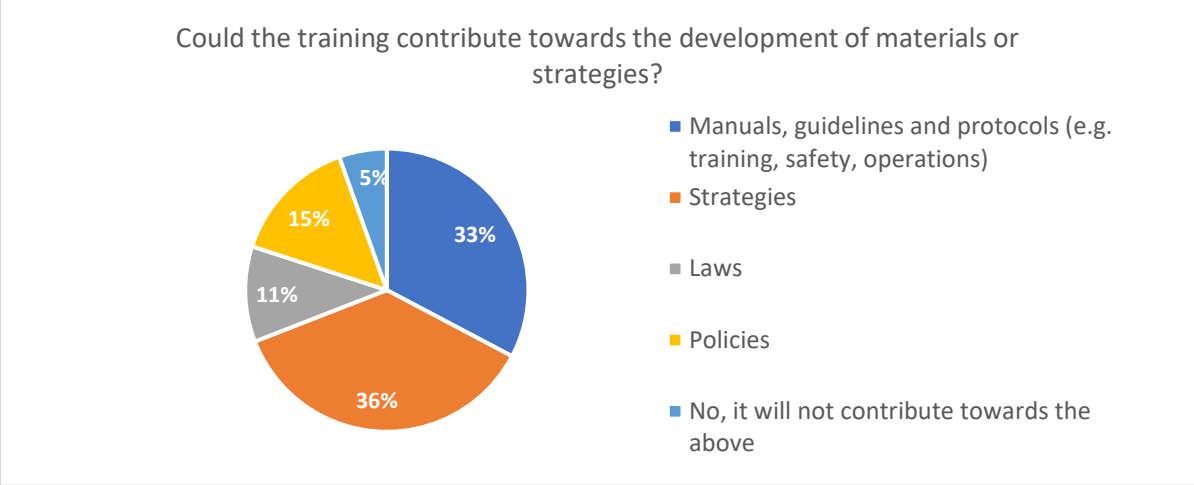
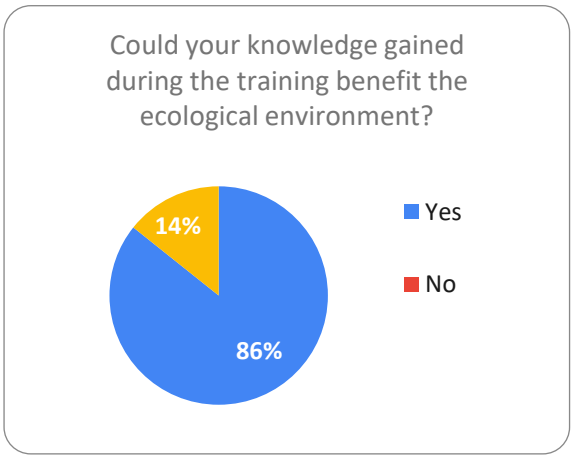


Figure 16: Contribution to development of materials or strategies

The indicator above (Figure 16) describes if the training could contribute to the development of certain materials or strategies. 36% of participants indicated strategies. 33% indicated manuals, guidelines and protocols (e.g. training, safety, operations), 15% says policies, 11% laws and 5% said that it will not contribute towards any of the above.



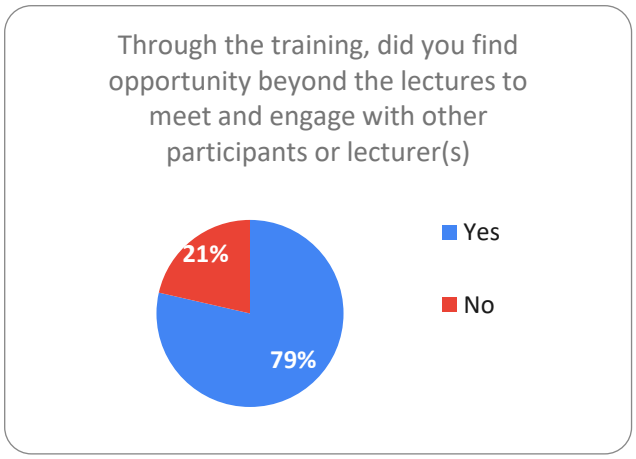


Figure 17: Benefit to ecological environment Figure 18: Interaction with other participants

Results related to the benefit of the ecological environment (Figure 17) revealed that 86% of SANWATCE partners indicated 'yes'. Results illustrated in Figure 18, had a similar trend with 79% indicated that through the training, participants were able to meet and engage with other participants and lectures.

8 Role of the SANWATCE Secretariat

The Secretariat coordinated project activities on behalf of the Network. These activities included:

- General project management and coordination
- Sub-contracting and providing guidance to CoEs where required including developing templates for reporting, financial reporting and general oversight.
- Creating awareness of regional and continental stakeholders of the project and progress through participation in activities such as the AU and AMCOW Joint Partners

meetings and the SADC Water Resources technical Committee in order to locate the project with broader regional and continental development and sector frameworks.

- Leading the development of the e-readiness assessment questionnaire as well as initial analysis of the data coming from the study.
- Providing support to the monitoring and evaluation personnel.

Some of the challenges experienced during this phase include inadequate clarity on the expectations of and from CoEs especially regarding changes in project deliverables and its implications on workload and financing activities.

9 COVID-19 Impact and Responses

Initially, training courses were planned for implementation in Botswana, Malawi, Mozambique and Zambia. These were to be offered via face-to-face delivery. However, plans were affected by the COVID-19 pandemic which necessitated, where possible, a shift towards online, blended and distance learning.

A risk mapping exercise and E-readiness evaluation were launched early into the COVID-19 pandemic by UNESCO. The risk mapping consisted of a questionnaire circulated to all CoEs and was launched in April 2020. Initial results from the risk mapping indicated that on-line learning and distance activities were seen as options for re-orientation if activity implementation trending to on-line options, but that there were current challenges and needs to be addressed.

An e-readiness assessment was conducted by Stellenbosch University, to understand to evaluate the current level of capacity of CoEs to implement distance and online courses for professional and technician levels during the remainder of the project. A questionnaire was administered to understand existing staff and institutional capabilities to deliver distance and online learning as well as access to hardware, software and technical support for the delivery. Overall, the assessment indicated that:

- Respondents from CoEs have had some training and experience in offering online learning
- Although with varying levels of readiness, institutions have the technical support necessary to roll out online learning
- Respondents are conversant with online learning platforms such as Zoom, MS Teams and Google Meet.
- Further training was required
- To a large extent, access to internet data was a problem for students

The following table summarizes the E-readiness assessment within the SANWATCE network. The table below illustrates CoEs current capacities i.e. materials & hardware; software, licenses, fees and data; HR, staff and tech support which ultimately affect their readiness for online e-learning – Low, Medium or High. The last two columns on the right indicate the CoEs' ultimate readiness for online e-learning – yes, no or partly.

Table 20: Summary of e-readiness assessment

CoE	Material & Equipment, Hardware: Low, Medium, High	Software, licenses, fees, data: Low, Medium, High	HR Costs, Staff, Tech Support: Low, Low; Medium, High	Ready for online e-learning Yes/No/Partly	Ready for blended learning: Yes/No/Partly
University of Botswana	Low	Medium	High	Partly	Partly
The University of Malawi	Medium	Medium	High	Yes	Yes
Universidade Eduardo Mondlane	Medium	Medium	High	Partly	Partly
Council for Scientific and Industrial Research (CSIR)	High	High	High	Partly	Partly
Stellenbosch University	Medium	High	High	Yes	Yes
University of KwaZulu-Natal	Medium	High	High	Partly	Partly
University of the Western Cape	Medium	Medium	High	Yes	Yes
University of Zambia	High	High	High	Yes	Yes

Following the e-readiness assessment and given project timelines, the University of Botswana opted out of implementing training courses. The Council for Scientific and Industrial Research and the University of the Western Cape opted to participate in the course implementation. The University of Malawi and UEM were able to implement face-to-face training courses.

10 Conclusion / Lessons Learned / Recommendations

The added value of the ACEWater2 HCD Component to HCD efforts in the SADC region is clear. The piloting has highlighted and/or reemphasised gaps in content/thematic areas. More importantly national processes identified challenges in the country HCD systems for junior professions and technicians and collectively formulated solutions. In summary these were:

- Inadequate implementation of existing policies, strategies and plans.
- Ad hoc HCD projects not necessarily aligned with broader national priority framework for HCD, thus, generally not responding to the needs of the industry.
- Inadequate coordination and resourcing of water sector JSPTL HCD initiatives.
- The need to strengthen and/or establish relevant CBIs, in particulate TVET institutions; and
- Inadequate partnerships between CBIs, government, national HCD units and industry (including water utilities and private companies), which must support practical aspects of training and ensure HCD efforts are demand responsive.

At the national and project level, each country indicated what their priority piloting activities were might be based on time frame, urgency and feasibility. Countries also considered their pilot activities strategically with regards to seeking further support and leveraging national budget and external funds to continue supporting their national JSPTL HCD processes. Countries are continuously promoting piloting priorities that further instil excitement and ownership through some aspects of the strategy being implemented.

Overall, some key lessons learned from implementation of the HCD component include:

- Important to be cognisant of and appreciate the context at both regional and national level in order for the frameworks to be responsive and the priorities to reflect sector capacity needs and aligned to national development aspirations. In so doing the HCD frameworks are crafted with a value proposition in mind
- Capacity development frameworks and initiative must be targeted at the entire water value chain. An understanding of the water value chain is critical in the development of HCD framework for a more nuanced understanding of the skills required for sustainable water resources management and water and sanitation service delivery at the national (and regional) level.
- The consultative process followed in developing HCD frameworks is key to sustainable and institutionalised HCD interventions. Going forward, process must define and inform subsequent stages of the programme so as to build ownership, ensure uptake and inform replication.
- The COVID-19 pandemic, whilst disruptive in its nature, has brought to the fore both the gaps in institutional readiness to deliver online training and the opportunities online learning presents to expanding learning opportunities. As part of implementing IPA 2, an assessment was conducted to check institutional readiness to offer course online. Results from the analysis indicated that there is need for further training of CoEs to better tailor, package and deliver online and distance learning. Similarly, ICT capacities at CoEs have to be strengthened as well as in the short term, partnering with internet service providers to ensure more affordable internet connectivity for learners. In the long run, government intervention in improving internet infrastructure and related policy will go a long way in ensuring affordable and accessible internet services that enable online learning.
- The need for regional and continental staff and student exchange programme cannot be overemphasised especially in its role in strengthening inter and intra networks collaboration. In addition, this can help to maximise on the available human capacity and high-end research infrastructure across the network
- CoE strengthening through the purchase of relevant infrastructure is key to human capacity development.

A few significant matters that need urgent attention:

i. The findings, gaps and value addition of the 5 country HCD processes need to be shared, presented and discussed with the SADC Water division, WaterNet and Global Water Partnership Southern Africa (GWPSA) among other regional stakeholders.
ii. The regional partners – including SANWATCE - should discuss and agree on sharing the approach and the results of the HCD process with the other SADC Member States and explore how best that can be done (for example at the symposium, WRTC, the WaterNet Management Board and GWPSA Board meetings and or other platforms)
iii. The short-term question is how can the other 10 (soon to be 11) SADC member states replicate the process to assess their challenges, gaps and come up with priority actions (as Botswana, Malawi, Mozambique RSA and Zambia have had the advantage of doing)?

iv. The longer-term matter for discussion is about how the regional partners (SADC, RBOs, WaterNet, SANWATCE, GWPSA and others can discuss a plan of action and support SADC Member States in addressing their JSPTL HCD needs, beyond the narrow confines of one project. Regional partners need to urgently strengthen their collaboration, resourcing and coordination towards equipping JSPTL with the essential capacity required.

v. Implementation of the HCD component developed a methodology for addressing HCD challenges in the water sector. While piloted in five of the sixteen countries in southern Africa, the methodology can be adapted and replicated in other countries. The consultative process of arriving at HCD frameworks facilitated ownership of the process and output by sector stakeholders. Frameworks can be used to leverage resources for ongoing HCD activities beyond the project. Ongoing committed activities, in Malawi and Zambia for example, based on the frameworks and resources externally attest to this.

Annex 1: SANWATCE list of detailed course contents

1.1 Malawi detailed course contents

The course contents for Malawi are as captured below. The two implemented courses were at the masters level and offered to existing enrolled students at the University of Malawi. and teaching materials are contained in a folder accompanying this report.

1.1.1 Hydrological Modelling & Water Quality Modelling Combined Course (implemented)

The course was aimed at equipping students with knowledge and skills in the development and use of hydrological and water quality models. Table 7 contains the course outline.

Duration (Hours)	Course content
7	Developments in hydrological modelling • The role of modelling • Objectives and concepts • Classification of models • Model components • model examples
7	Steps in hydrological modelling • Conceptualization • Model development • Calibration, verification and validation • Sensitivity analysis • Parameterisation
7	Flood routing • Hydrologic and hydraulic routing • Hydrologic reservoir routing • Governing equations for hydraulic river routing • Movement of a flood wave • Kinematic wave routing • Muskingum-Cunge method of hydraulic river routing
7	Groundwater Modelling • Conceptual model design and boundary types • Outline and flow of modelling methodology • Hydrogeological classification and boundary conditions • Estimation of aquifer parameters • Groundwater recharge and discharge • Model calibration and error analyses • Modelling of groundwater basins • Application of groundwater model • Geophysics
7	Water quality prediction and simulation • The “modelling” environment • Modelling water quality reactions • Water quality modelling in practice.
7	Individual Project: Modelling impacts of climate change and land use on hydrology & water quality

1.1.2 Water and sanitation systems (implemented)

The aim of this module was for students to understand the concepts and principles used in integrated planning and management of water resources and appropriate technical alternatives of water supply, wastewater management and sanitation infrastructure and services. Table 8 contains the course outline.

Duration (Hours)	Course content
3	Waters resources • The hydrological cycle • Spatial and temporal water distribution • Overview of Integrated Water Resources Management (IWRM) • Institutional roles - the organisational framework, capacity building • Water resources assessment - hydrological data, forecasting, groundwater, the environment, socio-economic assessments • Integrated Water Resource Management plans - physical interventions, socio-economic interventions
3	Water supply • Water demand characterisation and management • Principles, technologies and processes for water collection, delivery and storage • Quality measurement and parameters • Operation and maintenance of water supply infrastructure
3	Wastewater treatment • Surface water pollution • Sewage characteristics • Appropriate conventional and alternative treatment methods • Treatment and re-use of industrial wastewaters • Sewage treatment for small communities • Physical and biological treatment principles • Sludge treatment and disposal • Aerobic, anoxic and anaerobic treatment processes • Operation and maintenance.
3	Sanitation • Low-cost sanitation • Sub-surface effluent disposal • Pit latrines (options, design and construction) • Septic tanks and aqua privies, • Other family latrines, communal and institutional latrines • Latrine emptying and upgrading • Sanitation promotion and implementation • Sanitation for those with special needs • Emergency sanitation and their promotion, design, construction, operation and maintenance • Options when 'on-site' no longer works • Principles of ecological sanitation
6	Field Visit: Visit to a water infrastructure

1.1.3 Water supply

The aim of this module is to acquaint the student with the complex relationships that exist between: hydraulic, chemical, biological, economic and social factors in the construction and operation of water supply systems

Module	Topic
1	**Water Resources** • The hydrological cycle and water sources
2	**Planning Water supply systems** • Planning guidelines and water demand
3	**Fluids in motion** • Definitions of fluid flows, the control volume equation, the conservation laws of mass, energy and momentum, streamlines, Bernoulli's equation.
4	**Fluid friction** • Boundary layers on flat plates, skin friction drag, laminar and turbulent flows, Reynolds number, pipe friction, Darcy's equation, The Moody diagram, minor losses in pipes.
5	**Pipe flow** • Pipe flow regimes, significance of the laminar sub-layer, equivalent sand roughness size, application of Colebrook- White equation and Moody diagram
6	**Pipeline network analysis and design** • Frictional losses, secondary losses, methods of analysis and design (HRS charts, Hazen Williams's formula, Darcy-Weisbach, Hardy-Cross method, nodal method.
7	**Water distribution system** • Water intakes, water storage (tanks and reservoirs), pumps – types, choice and maintenance, pipes and pipe networks and pipe fittings.
8	**Water services design criteria** • Principles for design and construction of water and sanitation systems, planning and design standards, pressures, firefighting and depths of pipes
9	**Emergency water supplies** • Municipal and private water supplies.

1.2 Mozambique detailed course contents

The course contents for Mozambique are as captured below. Two courses, namely: Maintenance of Networks and Losses and Environmental Impact Assessment, were offered by the Universidade Eduardo Mondlane from 7 – 13 October 2020. Courses delivered were part of courses prioritised by stakeholders during Phase 1.

Both courses were offered using a face-to-face delivery. The teaching materials are contained in a folder accompanying this report.

1.2.1 Management and Maintenance of Networks and Water Loss (implemented)

This training was aimed at developing professional skills and abilities in management and maintenance of networks and water loss, with a view to guaranteeing rational and effective use of water, which will translate into the reduction of losses and the increase of coverage of water supply in the country.

Duration (Hours)	Course content
8	Introduction to Maintenance • Importance and Objectives of Maintenance • Concepts in Maintenance • Hygiene, health and safety at work (HSST)

8	SAA Facilities and Equipment Characteristics - Composition of Water Supply Systems
8	Maintenance Types and Tools • Corrective Maintenance • Preventive Maintenance • Predictive maintenance • Detective Maintenance • Maintenance tools
8	General Principles of Maintaining the Distribution Network • Planning of Maintenance Activities
8	Leak Detection • Measurement of Night Flow • Step test • IWA Water Balance

1.2.2 Environmental Impact Assessment (implemented)

This course has the general objective of training trainees in the field of environmental impact assessment.

Duration (Hours)	Course content
4	Introduction and Concepts • Environment • Environmental Impact • Ecology • Project Environmental Impact • Direct and Indirect Affected area • Others
8	Environmental legislation • Law 20/97 of 1st of October • Law 19/2007 of 18th July • Decree 45/2006 of 30th November • Decree 45/2004 of 29th September • Other Relevant legislation
8	Main documents for Environmental Licensing • Environmental impact study (EIA) and environmental impact report (RIMA) • Environmental impact monitoring and monitoring program
8	Environmental impact assessment methods • Ad Hoc" method • Control list method ("check-list") • Overlay mapping method ("overlay mapping") • Mathematical models method • Interaction matrix method
12	Reporting EIA and Mitigation measures for environmental impacts in different environments

1.2.3 Community Education

The course aims to building participants' skills and abilities in ensuring the functioning and development for water supply and sanitation programmes in both urban and rural areas of the country with the view of improving the living conditions of the populations .

Module	Topic
1	**General introduction** • Organisation; framework; general and specific objectives; learning outcomes
2	**Sector policies** • National Water Supply Strategy; National Sanitation Strategy; Water Policy; Implementation Manual for Rural Water Supply Projects; National Rural Water Supply and Sanitation Programme (PRONASAR)
3	**Participatory methodologies** • Participatory Hygiene and Sanitation Transformation (PHAST); Community Led Total Sanitation (CLTS); Child Hygiene and Sanitation Training (CHAST); Water, Sanitation and Hygiene (WASH) in schools
4	**Speciality training** • Participatory RuralAppraisal (PRA); Gender and development; quantitative data collection methods; studies on the population's behaviours, attitudes and practices; health education; well and borehole management; management of small water supply systems
5	**Construction, operations and maintenance** • Assembly and disassembly of Afridev hand pumps and the construction of sidewalks; low cost latrine construction

1.2.4 Water Quality Assessment

The general objective of the course is to train participants in the field of water quality assessment including the collection and preservation of samples and the adoption of proactive attitudes in their management

Module	Topic
1	**Introduction** • Importance of Water Quality Assessment; concepts related to water quality (water pollution, water contamination, drinking water, mineral water, brackish water, contaminants, pollutants, toxics, pure water, water impurities and sewage); diseases related to drinking unsafe water and contact with contaminated water; paths of disease transmission; general sampling rules; types of sampling
2	**Water quality legislation** • Water Law; Water Quality Regulations for human consumption; Water Quality Standards for Agriculture; Effluent emission standards
3	**Collection and sampling techniques** **Physical and chemical testing** • Types of bottles; washing of bottles; handling and transportation of samples; preservation and conservation of samples; sample volume required for each parameter to be analysed; deadlines / limits for analysis; equipment and materials used for sampling **Bacteriological testing**

	• Types of sample collection bottles; sample volume required for each parameter to be analysed; collection of samples in water distribution systems; collection of samples from wells / boreholes, springs, consumer taps, operational control points / surveillance points of distribution networks; preservation and deadlines / limits for analysis; equipment and materials used for sampling
4	**Biological testing** • Equipment used in biological analysis; sampling and analysis parameters; collection and preservation of samples, in rivers, lakes, lagoons and swamps
5	**Biological water quality assessment methods** • Biological water quality assessment parameters; aquatic species that indicate water quality; aquatic species that indicate water pollution
6	**Preparation of sample collection plans**
7	**Solutions** • Concentrations of substances; dilution of solutions; disinfectants; preserving and storage of samples
8	**Methods of microbiological analysis of water for human consumption** • Definitions and theoretical aspects; sampling and analysis parameters; analytical methods in microbiology; statistical analysis of laboratory results
9	**Methods of Physicochemical Analysis of Water for Human Consumption** • Definitions and theoretical aspects; sampling and analysis parameters; analytical methods in physical chemistry; statistical analysis of laboratory results

1.3 South Africa - CSIR detailed course contents

The Council for Scientific and Industrial Research (CSIR) collaborated with the University of the Western Cape (UWC) to deliver a course entitled Environmental Assessment and Management. The CSIR component of this one semester course concentrated on translating academic knowledge to the workplace environment hence practical and skills components to the course. This component was prepared and offered by CSIR and ran from 31 August - 04 September 2020. The course was delivered through online learning using Ikamva (a UWC learning portal) and Google Meet. The course contents are as captured below, and the course material is contained in a folder accompanying this report.

1.3.1 Environmental Assessment and Management – IWRM and the Workplace (implemented)

Duration **Hours**	**Course content**
Week 6 **(31 August - 04 September 2020)** **8 hours/day**	**CSIR component** **Integrated Water Resources Management (IWRM) and the Workplace** Academic knowledge on 1] Water Resources Management; 2] Water Resources Governance and Management; and 3] Environmental Assessment and Management versus Application of Knowledge in Workplace Environment The discussion for the week will be on the following topics:

	• Relevance of academic qualification at workplace [Government Space/Sector, Consultancy Space/Sector and Industrials Space/ Sector] • What are the roles of a graduate at workplace [Expectations]? • How should a graduate operate at workplace [Expectations]? • How should a graduate integrate [fit] in existing workplace structure [Expectations]? • What are dos and do not practices and behaviours at workplace [Expectations]?
Practical Tasks	Some of practical tasks on compiling and using water resources data and information: • Examine sources of hydro information from AQUASTAT; FAOSTAT; UN-WATER; SADC; WHO; UNESCO; WETSPRO; WRC; DWS database; GW Chart information; Hydstra information (level, quality, rainfall). • Analyse examples about water assessment, monitoring, quality, protection data and reports, maps, documents, brochures and data management

1.4 South Africa - UWC detailed course contents

Two courses, namely: Water Demand Management & Water Security (Water, human security and Development) and Introduction to Groundwater Hydrology, were offered by the University of the Western Cape from 17 August - 25 September 2020 and 27 July – 4 September 2020 respectively. Both courses were offered online using both synchronous (4 hours daily) – via Ikamva and Google Meet and asynchronous (4 hours daily) methods. The course contents are as captured below, and the course material is contained in a folder accompanying this report.

1.4.1 Water Demand Management & Water Security (implemented)

The course emphasises on human security and development and pays particular attention to managing water resources for the betterment of all by understanding the socio economic and political dynamics around water resources.

Duration **Week**	**Course content**
1	Human security & Development; water in the world • State security • Human security • Vulnerability and risk • Water availability and use
2	Water availability – How much water is there? • Understanding the concept of water availability • Measuring water availability • Occurrences of water in space and time • Balancing water for humans and nature
3	Water and security • Water security • Water and climate change • Understanding indicators for water availability • The gendered nature of water resources
4	Water for health and water for cities • Water and health

	• The state of water, sanitation and hygiene • WASH governance and management • The demographic transition • Urbanisation challenges • Pro-poor urban water and sanitation governance • Systems for supply
5	Water for food • Increasing yields in the savannah • Managing green water flows and appropriate technologies • Virtual water • Biophysical; socio-political; and socio-economic challenges
6	Rural water supply • The rural – urban continuum • Informal and formal water supply systems • Criteria for water supply • Pressures on supply • Case study: Botswana

1.4.2 Introduction to Groundwater Hydrology (implemented)

The course aims to improve learners understanding of the scientific aspects of groundwater with a focus on definitions, concepts and principles underlying the quantity, quality, and management aspects of the resource.

Duration Week	**Course content**
1	Hydrogeologic System • Groundwater processes [Overview on Recharge, Flow & Discharge] • Aquifers: Aquifer occurrences and aquifer types • Aquifers: Aquifer Properties and aquifer parameters
2	Groundwater occurrences [Recharge system] • Recharge system: [Types & factors] • General methods for estimating groundwater recharge • Natural recharge: Factors and methods • Artificial recharge: Factors and methods
3	Groundwater hydraulics [Flow system] • GW flow mechanisms & flows in aquifers & flow to wells • Flow processes and continuity; groundwater Flow head • Groundwater flow types, flow directions and groundwater mapping • Groundwater hydrologic measurements and GW flow analyses • Regional and local groundwater flows & GW conceptual models • Introduction to fluid mechanics: Principles and application • Darcy's Law, hydraulic conductivity, Transmissivity & Storativity • Pumping Tests [Types and methods] • Methods for parameter estimations • Groundwater balance [inflows and outflows]
4	Groundwater-Surface water Interaction [Discharge system] • Groundwater dependence ecosystem: Discharge system • SW-GW Interactions in various settings/environments • Methods for assessing interactions • Natural discharge: Factors and methods • Artificial discharge: Factors and methods

5	Groundwater development [Case study: Hospitals and schools] • Groundwater exploration • Groundwater drilling & construction • Groundwater development [Cleaning up the borehole] • Aquifer testing [Yield plus others]
6	Groundwater & mining environment • Geohydrology in the mining environment • Geohydrology in the farming environment • Geohydrology in the water supply environment

1.5 Zambia - detailed course contents

The course contents for Zambia are as captured below. The University of Zambia developed a course on Drilling Methods and Well Completion for implementation. However, due to the COVID-19 pandemic, the course could not be offered within the project timelines. Preparatory work for the course included:

- Development of course material
- Engagement with the Water Management Authority and the Drillers Association of Zambia to collaborate on the course
- Discussions with the Department of Planning with the Ministry of Water Development Sanitation and Environmental Protection
- Agreement with the Water Management Authority for recognition and certification of the course
- Agreement with the Natural Resources Development College to co-deliver the course

1.5.1 Hydrogeology and Drilling Supervision Training (full course developed)

Groundwater has become the principal source of water for many in rural communities and urban areas. As the result, groundwater development in Zambia has increased and borehole drilling has grown exponentially in recent years. However, the lifespan of these newly developed boreholes is declining dramatically. This means improvement in drilling capacity and borehole completion is fundamental. To address this, this course intends to develop skills and knowledge of key professionals to supervise borehole drilling, properly document the process and solve onsite problems during the construction of boreholes.

Module	Topic
1	**Groundwater exploration and exploitation** • Drilling concepts and methods • Well design and development • Occupational health, safety and environment in drilling • Practical drilling e.g., Mud drilling and DTH • Operation and maintenance of drilling machinery and accessories • Well maintenance and rehabilitation • Field data forms and regulatory requirements
2	**Aquifer evaluation** • Pumping test analysis methods • Pump test data analysis • Well construction and design
3	**Groundwater monitoring and information management** • Types of information to be collected before and after drilling

	• Introduction to the groundwater information management system • Geodin database • Basic operations of geodin (import and export, data entry, queries and outputs) • Construction, installation and development of monitoring wells

1.5.2 Water resources monitoring

The aim of the course is to allow students to gain an understanding of the electronic water resources databases and archives and how these are formulated, stored, analysed and managed. Candidates will also become knowledgeable on the field methods used in surface and groundwater mapping, on the use of the Remote Sensing and Geographic Information System (GIS), and Geophysics techniques in water resources. This module will also allow students to develop skills on how to relate water resources to climate change.

Module	Topic
1	Water Resources (quantity and quality) in Zambia
2	Electronic water resources databases and archives
3	Field methods of surface and groundwater
4	Remote Sensing & GIS
5	Geophysics (introductory)
6	Climate Change

1.5.3 Water Environmental quality modelling

The modelling of environmental processes infuses the much needed science in what can be a very speculative area with a myriad of uncorroborated interpretations. The quantitative and simulation techniques provide a sound basis for analysing and interpreting everyday environmental phenomena which is very important in the practice of environmental engineering.

The aim of the course is to equip students with the basic concept of mathematical modelling and process simulation techniques of environmental disturbances with reference to air, water and groundwater domains

Module	Topic
1	**Modelling concepts** • Casual and statistical models-Characteristics-Steps in model development - Importance of model building. conservation of mass and mass balance-calibration and verification of models;
2	**Transport phenomena** • Advection, diffusion, dispersion, simple transport models; chemical reaction kinetics-Law of mass action, rate constants, reaction order, types of reactions, equilibrium principles; Water quality models:
3	**Air pollution modelling** • Chemistry of air pollutants, atmospheric reactions, sinks for air pollution, transport of air Pollutants-Meteorological settling for dispersal of air pollutants-Vertical structure of temperature and stability, atmospheric motions, wind and shear, self-cleaning of atmosphere; transport and diffusion of stack emissions-atmospheric characteristics significant to transport and diffusion of stack emission-stack plume characteristics; Air quality models: Types modelling technique, modelling for nonreactive pollutants, multiple sources and area sources, fixed box models- diffusion models, model performance, accuracy and utilization; Software package applications Air quality modelling and water quality modelling.

1.5.4 Field hydrogeology

This course is offered to drillers and technicians with limited knowledge on hydrogeology. The objective of the course is mainly to expose participants on the geology of Zambia, identification of rock, the basics of hydrogeology and field data collection methods. Emphasis is on skills that are required to facilitate government requirements in borehole completion reports.

Module	Topic
1	**Basic geology** • Introduction to Geology; minerals; applied geology; rocks (sedimentary, igneous and metamorphic); structural geology (BU) (structural discontinuities, geological maps and interpretation)
2	**Basic hydrogeology** • Groundwater utilization and basic hydrogeology concepts; hydrological cycle; groundwater in Zambia; groundwater occurrences; groundwater flow; groundwater equations and well hydraulics; exploration methods
3	**Groundwater management and regulation** • WARMA Act - Overview and highlights; role of drillers in groundwater management; water quality and contamination; groundwater and climate change; groundwater information system (GeoDIN)

1.6 Botswana detailed course contents

Even though Botswana did not participate in the implementation phase due to COVID-19 restrictions, the University of Botswana had provided the course contents for all four planned courses, as captured below.

1.6.1 Advanced hydrology

The aim of this course is to equip the students with advanced skills in modelling of hydrologic variables for water resources planning and management, including hands on experiences on applications of some selected software. This will be achieved by discussing the concept of modelling using deterministic, statistical and stochastic processes for the purpose of water resources management. Applying these models as well as others, such as conceptual hydrologic models, newer methods of parameter estimation for use in hydrological forecasting and prediction problems will be the focus of this course. The learners will also be exposed to some of the available tools and software commonly used in Hydrology, Water resources modelling and management. As an advanced course, it will focus on applied hydrological techniques with a bias towards addressing the peculiarities of semi-arid environments.

Module	Topic
1	**Hydrological processes and landforms; Surface water-groundwater (sw-gw) interactions:** Key hydrological/hydrogeological concepts and processes-the resultant landforms; concepts underlying sw-gw interactions, conditions leading to surface water-groundwater interactions, impact of sw-gw interactions, integrated hydrological modelling framework.
2	**Ungauged catchments:** Concept of regionalisation and use of some methods which use catchment characteristics and are based on use of index flood procedures with LMoments
3	**Hydrological Modelling:** Classification of hydrological models, Model selection, Model calibration and validation; Parameter identifiability and sensitivity, uncertainty analysis.

4	**Climate change and hydrology**: Key concepts and main drivers of climate change related to hydrological systems, Climate change models, scenarios, impacts and analyses; Concepts of model downscaling for hydrological applications.
5	**Hydrological forecasting:** Introduction to deterministic, conceptual and stochastic models, concept of Instantaneous Unit Hydrograph (IUH) and its use in rainfall-runoff modelling. Flow forecasting using Clarke and some commonly used stochastic models viz: Auto Regressive (AR), Moving Average (MA), Auto regressive Moving average (ARMA) and Auto regressive integrated moving average (ARIMA).
6	**Hydrological prediction and extreme value analysis:** Introduction to various 2, 3 and 4 parameter statistical models (viz: EV-1, Exponential, Gamma, GEV, Pearson Type III and Kappa) used for prediction of hydrological extremes. Introduction to advanced parameter estimation techniques such as: Method of Maximum Likelihood, Probability Weighted Moments and L-Moments. Use of Monte-Carlo simulation technique for appropriate choice of parameter estimation technique. Analyses of floods and droughts with extra-ordinary events.
7	Submission of Mini projects and revision

1.6.2 Water resources management

The aim of this course is to examine processes, tools and instruments that are vital to the appraisal and/or optimization of water resources for competing uses. With water resources management fast becoming complex due to several anthropogenic activities, the ongoing changes in climate and increasing competing needs, there is no doubt that human resources development within the field of water resources supply systems should be a priority, especially for semi-arid environments. The prime objective of most public water resources development projects is the maximization of national welfare. This complex management scheme is manipulated, invariably, by reservoir constructions, which have to be planned and operated in accordance with some prescribed optimization rules and objectives which balance between the social, economic and the environment. It is thus critical that students are assimilated into this area if we are to use our water resources sustainably. Overall the course will enable the students to better comprehend the whole water resources planning, development and management process.

Module	Topic
1	**Water resources planning and development** Perspectives on water and Environmental issues, System components, Network planning and design, Storage, Analysis, Impact of urbanisation and storage structures on the environment and hydrological processes.
2	**Regulation of reservoirs:** Balancing water supply with demands, water balance of reservoirs as a tool in reservoir design and management.
3	**Reservoirs and sedimentation**: Determination of sediment yield, Analysis of relations between sediment yield and discharge, Empirical relations for total sediment load, classification of reservoirs, distribution of sediments in reservoirs, reservoir sediment control. Water Resources and Public Health.
4	**Integrated Water Resources Management (IWRM):** IWRM principles and toolbox, some commonly used methods of water conservation and other demand management strategies, trans-boundary river/aquifer management issues, river basin/aquifer management, water allocation issues, processes and conflict resolution.

5	**Economic aspects of reservoirs**: Cost benefit ratios, optimization of benefits, linear programming in multiple purpose water resource projects, economic mechanisms of managing water resources (pricing, permits and markets)
6	Presentations of group work

1.6.3 Applied and field hydrology for practitioners

The aim of this course is to appraise learners with relevant and new techniques, latest developments/debates relating to hydrological applications and analysis for improved water resources development and management. This will be achieved by discussing the classic methods used for addressing hydrological problems in gauged and ungauged catchments, development of appropriate trends analysis methods, appreciation of different types of models used in hydrology (deterministic, stochastic and statistical), analysis of extreme events and risk analysis and mitigation measures. The participants will be exposed to latest techniques used for hydrometric measurements, analysis and interpretation, development of rating curves, their application and relevance in hydrology. Teaching materials such as videos on the use of gauging instruments will be employed as well as hands on experience and field visits to complement classroom lectures.

Module	Topic
1	• **Water Resources of Botswana (Surface and Groundwater distribution)** • **Climate of Botswana and its influence** • **Climate Change considerations** *(Science of Climate Change, SDGs, Adaptation and Mitigation measures)*
2	**Data Quality Assurance and Analysis** • Techniques of Infilling Missing Data; assessment of quality of data (Double Mass procedure); Data analysis and summary statistical parameters *Exercise 1: Infilling of missing data* **Hydrometry** • Site Selection (Factors to consider); controls and streamflow measurements *Videos on use of current meters*
3	***Hydrometry continues*** • Gauging methods and their importance; Rating Curve development and analysis ***Use of drones for hydrometric assessment (Theory and practical)*** *Exercise 2: Computation of discharge* *Site Visit to Gauging Station*
4	**Trends, Intervention Analysis** *Exercise 3: Trends and analysis* **Hydrologic Modelling using selected tools/software** *Exercise 4: Modelling (model parameter selection, identifiability and sensitivity)*
5	**Development of Flow Duration Curve and its use** **Probability Analysis, Frequency and Risk Analysis of Extreme Events** *Exercise 5: FDC & Design Flood Computation*
6	**Unit Hydrograph , Derivation** **Synthetic UH, Dimensionless UH** *Exercise 6: Development of a Unit Hydrograph and interpretation*
7	**Prediction in Ungauged Basins- Concept; Water Balance Studies, Evaporation estimation methods** *Exercise 7: Water Balance* **Critical Sequencing of Rainfall Excess for Flood Forecasting** *Exercise 8: On Flood forecasting*
8	**Newer Methods of Parameter Estimation (PWM, MML)** **Identification of Homogeneous Regions, Catchment Characteristics** **Multivariate analysis using Catchment Characteristics**
9	*Exercise 9: On PWM, MML* *Exercise 10: On Multivariate Analysis*
10	**Stochastic Modelling**

	Exercise 11: On Markov's Model
11	**Clarifications/Discussions** **Assessment (Test)**

1.6.4 Principles of hydrology for technicians and artisans

The aim of this course is to equip learners with relevant and new techniques on handling hydrological problems for improved water resources development and management. This will be achieved by discussing the concept of hydrological cycle and overall movement of water within the biosphere, the importance of data, its collection, handling, storage and analysis to ensure quality outputs. The participants will be exposed to various ways of undertaking hydrometric and rainfall measurements, analysis and interpretation, development of rating curves, their application and relevance in hydrology. Teaching materials (such as videos on the use of gauging instruments), Hands on exercises and Field visits will complement classroom lectures.

Module	Topic
1	• **Water Resources of Botswana (Surface and Groundwater distribution)** • **Climate of Botswana and its influence**
2	**Data Quality Assurance and Analysis** • Data Collection, Storage and documentation (Importance of Metadata); data analysis and summary statistical parameters *Exercise 1: On data Analysis*
3	**Rainfall and Infiltration measurement and analysis** • Types of Rain gauges; requirements for setting up instrumentation; infiltration measurement (theory and field work); rainfall analysis and Techniques for Spatial rainfall computation and uses ***Field work: Infiltration measurement*** *Exercise 2: On Computation of Infiltration rates* *Exercise 3: On spatial rainfall analysis*
4	**Hydrometry** • Controls and streamflow measurements; gauging methods and their importance • Videos on use of current meters *Exercise 4: On Computation of streamflow* *Site Visit to Gauging Station*
5	**Discussion on site visit and other issues** **Assessment (Test)**

Annex 2: SANWATCE Exchange Programme Report

THE UNIVERSITY OF ZAMBIA

Lusaka

School of Mines

INTEGRATED WATER RESOURCES MANAGEMENT CENTRE

DEPARTMENT OF GEOLOGY

EXCHANGE STUDENT REPORT AT THE UNIVERSITY OF WESTERN CAPE, SOUTH AFRICA

Mulema Mataa

Degree Programme: Master of Science in Integrated Water Resources Management

Supervisor: Dr Kawawa Banda.

Executive Summary

The NEPAD Water Centres of Excellence sponsored student exchange program at the University of the Western Cape started on 15th February 2020. The program was supposed to last for 60 days until the 14th April 2020 but due to circumstances beyond our control, the exchange program ended on 25th March 2020. During this period, I participated in Hydrogeology and Advanced GIS lecturers and practicals, monthly seminar presentations and 12 hours pumping tests. The university also provided free access to online literature from various publication companies that I am using for my thesis writing. Stable water isotope samples were dispatched to ithemba laboratory and Major ion water samples were delivered to Elsenberg laboratory for analysis. Analysis of the water samples is being conducted and I await the results for further interpretation. The major challenge experienced during the exchange program was from anion analysis, the 50 ml sample size was not sufficient for all

the anions I needed to be analysed. The exchange program was cut short after the outbreak of the COVID-19 that led to the closure of the University.

Table of Contents

Abbreviations

EC – Electrical Conductivity

GIS – Geographical Information System

PhD – Doctor of Philosophy

SADC - Southern African Development Community

UNZA- University of Zambia

UWC – University of the Western Cape

1.0 Introduction.

The NEPAD Water Centres of Excellence (NEPAD Water CoE) is a network of Higher Education- and Research institutions who conduct high-end scientific research on water and related sectors, in order to provide policy guidelines to governments. The NEPAD centre of Excellence consists of seven countries in the SADC-region countries including Zambia. Their mandate encompasses the facilitation and where applicable conduct selective research on water issues. To serve as a Higher Education (PhD; Post-Doc; Staff-Exchange) soundboard to the SADC region on regional water matters and to collaborate with other networks and institutions in specialised areas.

Through their collative network with the University of Zambia in the water sector, I was accorded the opportunity to analyse my water samples at the University of the Western Cape (UWC). The exchange program exposed me to researchers in the water sector who have vast experience in groundwater and surface water studies. I also interacted with researchers in Geographical Information Science and Earth Observation.

The exchange programme exposed me to scholars in the field of water science at UWC and we have been sharing articles and reports that are of importance in our research. I was exposed to other learning methods used at the University of the Western Cape that I will share with my colleagues at the University of Zambia.

Through the knowledge obtained from interacting with various researchers and scholars at the University of the Western Cape, I hope this strengthen linkages and collaborative work between University of Zambia and the University of the Western Cape. This report therefore details my activities during my stay and next steps going forward.

1.2 Objectives

1. To conduct stable isotope and major ion chemistry analysis on water samples
2. To attend classes in Hydrogeology and Advanced GIS
3. To interact with staff and students at UWC working on similar research themes

1.3 Activities

1.3.1 Week One

During my first week at UWC, I participated in class activities and a field excursion. The class was Integrated Water Resource Management module taught by Dr T. Kanyerere. With the topic: Integrated Catchment Management. The other class was Hydrogeology module taught by Dr Israel and the topic was water quality.

Practical

PHREEQC computer program to determine the molarities and saturation indices of different types of water i.e. Coastal groundwater, inland groundwater and rain water. To determine the outcome when inland water mixes with coastal water in a certain ratio and what would happen to saturation if desert conditions (increased temperature and reduced precipitation) were considered.

On Friday 21st February 2020. We had a 12 hours pumping test from 5:00 PM to 5:00 AM the following day at the monitoring boreholes within campus. The water was sampled for water chemistry analysis and onsite reading of temperature, EC, pH and radon-222. Radon-222 in water was measured using a RAD-7 Radon Detector shown in fig.1. The equipment is used to measure radon-222 in air but this particular one was modified to measure radon-222 in water. The units are Becquerel's per cubic meter (Bq/m^3).

Figure 1. RAD 7 Radon Detector.

1.3.2 Week two

In the second week of classes, I participated in the Hydrogeology Module taught by Mr. Siyamthanda Gxokwe. On the last Friday of February, we had Seminar Presentations with Dr Thokozani Kanyerere and his first year Masters students.

Practical

Hydrogeology practical with Mr. Siyamthanda Gxokwe using Pumping Test Pro to determine the Storativity and Transmissivity of the monitoring boreholes from the 12 hours pumping test conducted the previous week.

1.3.3 Week three

In the third week, I participated in Advanced GIS module taught by Prof Timothy Dube. During the lecture session, we reviewed papers with the Honours students. Two papers were reviewed, one by Zhou et al., 2013 'Groundwater-dependent distribution of vegetation in Hailiutu River catchment, a semi-arid region in China' and the other by Li et al, 2014 'Analysis of Landsat-8 OLI imagery for land surface water mapping'.

Water Analysis

Water samples were dispatched to Bemlab for major ion analysis. The laboratory could only analyse for cations because the volume (50 ml) was not sufficient for anions.

1.3.4 Week four

In the fourth week, I participated in Hydrogeology module taught by Mr. Siyamthanda Gxokwe under the topic: Numerical flow modelling. Followed by a practical for groundwater modelling using MODFLOW-2005 for simulation.

Water Analysis

Major ions

Mr. Evan the chief technician at the department of Environment and Water Science agreed that his laboratory could analyse some of the anions with the 50 ml sample volume but there was need to buy reagents and consumables as the department had run out of the supplies they had.

Stable Isotope

We contacted Mr. Mike Butler from Ithemba Labs, who agreed to conduct the stable isotope analysis provided we showed him proof of registration and the approved proposal. We later sent the documentations and he gave a go ahead to transport the samples.

1.3.5 Week five

In the fifth week, we had no lectures because the honours students were writing their end of team tests.

Major ion

We concluded that the water samples be analysed from Elsenburg Laboratories. Because they were able to analyse at least two anions in the 50 ml and it was better for one laboratory perform all the major ion analysis. We later contacted Bemlabs to cancel the analysis and during the course of the day, we collected the water samples. The water samples were packaged and sent to the post office for courier to Elsenburg.

Stable Isotope

The stable water isotope samples had to be repackaged in 1.5ml bottles as seen in fig.2 and sent to Ithemba laboratories because Mr. Mike Butler only required that much volume of sample for stable isotope analysis. The water samples were transported and Mr. Butler gave confirmation of receipt. The remaining sample volume was sent to Elsenburg laboratory to be used for anion analysis.

Fig. 2 A. showing a single bottle and B. Showing all the 93 bottles.

Both labs confirmed receipt of the water samples and commenced analysis.

1.3.6 Week six

In the sixth week, The University of the Western Cape was closed due to increased cases of COVID-19 in South Africa and Western Cape in particular.

2.0 Lesson learnt

The main objective of the exchange program was to analyse the water samples for stable water isotopes and major ion chemistry. This objective was met as the water samples are in the designated laboratories and analysis was being conducted before the country went on lockdown.

Part of my exchange program required I learn some modules with the Honours students. Hydrogeology module and advanced GIS module were chosen as the appropriate modules in line with my studies. I attended classes for 4 weeks until the end of the 1st term on 18th March 2020. During my stay at the University of the Western Cape, I was exposed to various software from groundwater software i.e. Aquachem, PHREEQC and Aquifer test pro to groundwater modelling software MODFLOW-2005. The University provided free online access to literature from Elsevier to downloaded articles for my final thesis writing.

The major challenge experienced was from major ion analysis. The volume (50 ml) I took to South Africa was less than the standard required for analysis. Bemlab was the first laboratory we contacted and they required at least 1 litre per sample. Bemlab could only analyse for major cations (Magnesium, Potassium, Sodium and Calcium) from the 50 ml sample but could not analyse any anions (chloride, sulphate, bicarbonate and sulphate). After consultation, we agreed to Bemlab analysing cations as we tried to engage another laboratories to analyse anions. The analysis of Major ions from two different laboratories sparked questions whether I was comparing laboratories. Furthermore, concerns whether the charge balance was going to be less than 15 %, considering different methods used by laboratories for analysis. Elsenburg laboratories was then contacted to analyse the anions, from the quotation received their pricing was cheaper than Bemlabs and they could analyse at most two anions from 50 ml volume. We then contacted Bemlabs to cancel our earlier request to analyse cations and later collected the samples. Elsenberg laboratories required at least 250 ml for the analysis of all the anions. The 50 ml was adequate for one parameter only, so we asked Mr. Butler from Ithemba labs how much volume he required for stable isotopes. Confirmation come through that he only needed 1.5 ml, which I transferred into small cups and the remaining sample was sent to Elsenberg laboratories. Two anions Bicarbonate (HCO_3^-) and Sulphate (SO_4^-) were set as priority in the analysis. If there be leftover sample the lab will analyse Chloride (Cl^-) and Nitrate (NO_3^-). Chlorides and sulphates are essential anions to determine the charge balance. According to Hydro chemists' interpretation of results without determining the charge balance error is regarded as sufficiently unreliable and cannot be justified for scientific purposes.

Due to COVID-19, all the analysis was suspended until further notice. The water samples are with the respective laboratories and will resume analysis as soon as the situation is under control.

Overall, I had a great experience at the University of the Western Cape and I gained a lot of knowledge through classes and interaction with researchers in the water sector. This opportunity broadened my understanding of my study and exposed me to different ways of conducting research.

2.1 Results and knowledge

The results from hydrochemistry will help evaluate hydro-chemical processes responsible for temporal and spatial changes in the chemistry of groundwater and surface water, while the results from stable isotope chemistry will be used to trace the origin, source, sinks and interactions in groundwater and surface water. Hydro chemical and stable isotope analyses will be coupled to assess and characterize the interaction between groundwater and surface water in the study area.

I intend to use the software's introduced to in the interpretation of the results from the analysis being conducted from the two laboratories. Some of the skills gained will be applied in writing my final thesis but mostly the knowledge will enhance my effectiveness as a researcher and scholar. I hope to eventually become a lecturer and thus be able to pass on these skills to new students and thereby improve the capacity of my university to conduct related research and development.

2.2 Suggestions for improvements of the exchange

It would be important for exchange student to join at the beginning of the term, especially if the student will be participating in classes at the host university.

The network should help sponsor some analysis locally to avoid the inconvenience of transporting bulky samples.

Host University supervisor assigned to exchange students should co-supervise a particular section of the supervisor's expertise in the research.

3.0 Acknowledgement

Many thanks go to Dr Kawawa Banda my supervisor, The NEPAD SANWATCE team Joanna Fatch, Norma Derby and others I did not interact with directly. From the Host university Dr T. Kanyerere, Mrs Chantel Carnow, Dr S. Israel, Prof. T. Dube and Mr Siyamthanda Gxokwe. The Masters students at the University of the Western Cape that welcomed me and kept me in high spirit during my stay at UWC, Jessie Kanyerere, Robert Lebese, Refiloe Maphiri and Ndubuisi Igwebuike. To you all I am very grateful and may God continue blessing you.