The impact of the ACEWATER Project

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Chapter 1: Overview and Background

1.1 Background to the AUDA NEPAD Networks of Water Centres of Excellence

It has been more than 20 years, since September 2000, when African countries and the international community adopted the Millennium Development Goals at the United Nations Millennium Summit. African leaders identified water scarcity and related insecurity due to water stress as one of the sources of the continent’s underdevelopment and increasing social and economic decline.

The first African Ministerial Council on Science and Technology (AMCOST), held in Johannesburg in 2003, decided on water science and technology (S&T) to constitute one of the main flagship programmes of the African Union / New Partnership for African Development (AU/NEPAD). Thus, in the framework of the AU/NEPAD, the leaders have committed themselves to “ensure sustainable access to safe and adequate clean water supply and sanitation, especially for the poor”. They decided that Science and Technology (S&T) will play an important role in water development, supply and management and that S&T is crucial for assessing, monitoring and ensuring water quality. The flagship programme should strengthen the continent’s capabilities to harness and apply S&T to address the challenges of securing adequate clean water as well as managing the continent’s resources to become a basis for national and regional cooperation and development.

On 22 November 2006, the African Ministers responsible for science, technology and water (AMCOST and African Ministerial Conference on Water, AMCow) met in Cairo, Egypt. By resolution, the delegates committed themselves to establish African Networks of Centres of Excellence in Water Sciences and Technology Development (further referred to as AUDA-NEPAD\(^1\) Networks of WCoEs).

Since the mid-2000s, resources (human and financial) from various organisations have been mobilised in support of the AUDA-NEPAD Networks of Water CoEs. Direct funding has been mobilised from the European Commission (as the ACEWATER Project), the South African Department of Science and Technology (SA-DST) to directly support the Secretariat of the Southern African Network of Water Centres of Excellence (SANWATCE).

\(^1\) In 2018/19, the AU-NEPAD became the African Union Development Agency – NEPAD (AUDA-NEPAD)
since 2009. The African Union (AU) provided funding for a research project on the use of Integrated Water Resource Management (IWRM) for development, involving members from SANWATCE and WANWATCE (2013 to 2015). In addition, the South African Department of Water and Sanitation (SA-DWS) has also provided financial support to the SANWATCE-secretariat in 2015 and 2018 with the South African Water Research Commission (WRC) supporting projects within the SANWATCE network. In West Africa, the Organisation pour la mise en valeur du fleuve Sénégal (OMVS) supported various research and capacity development initiatives, notable through the WANWATCE Secretariat at the Cheikh Anta Diop University in Dakar, Senegal. These are just examples of direct funding, as member institutions within the AUDA-NEPAD Networks of Water CoEs also mobilised funding through research and related activities.

Considering that the initiative was mandated by AMCOW and AMCOST, progress has been reported to various institutions and platforms, which include regular presentations and reports to AMCOW, the African Union (AU), the European Commission, UNESCO-IHP, the SADC Ministers of Water and also SADC ministers of Science and Technology and Education, the Economic Community of West African States (ECOWAS) and various ministerial and governmental forums. In addition, project reports were submitted to implementing partners such as the DST/NRF in Southern Africa, with the European Commission initiating a project-specific ROM review in 2017.

1.2 The ACEWATER project.

Following this resolution by AMCOW and AMCOST in 2006, the European Commission (EC) initiated a process to support the establishment of African Networks of Water Centres of Excellence, thus the birth of the Africa Centres of Excellence in Water Sciences (ACEWATER) project. Over just ten years, the ACEWATER Project was implemented in two phases, with ACEWATER I implemented between 2009 and 2014, and ACEWATER II implemented between 2016 and 2020. It was through this funding, that two initial networks of WCoEs were established in West Africa (WANWATCE) and Southern Africa (SANWATCE) in 2008. Later, in 2016, an AUDA-NEPAD Network of WCoEs was established in Central/East Africa (CEANWATCE) as part of ACEWATER II.

Currently, the three AUDA-NEPAD Networks of Water CoEs consist of 20 Universities and research institutions from 16 African Member States (refer to Annexure A for a list of member institutions). All Network members participated in shared activities such as joint-learning, knowledge management (as part of ACEWATER I) with additional research, human capacity development, infrastructure, and staff and student exchange for mobility
and research in ACEWATER II. These activities were implemented to support and to build a functioning and shared network identity between the members of the networks. ACEWATER II included dedicated actions aimed at research for policy which was coordinated through the EC Joint Research Centre in Ispra, Italy. Such research was undertaken in various transboundary river basins in Southern-, Western and Eastern Africa. In addition, ACEWATER II consisted of an action aimed at Human Capacity Development (HCD), which was implemented with resources and technical support from UNESCO-IHP.
Chapter 2: The objective of the Impact Study.

This study aims to identify and report on the impact (or benefit) of research activities from Phase 2 of the ACEWATER (ACEWATER II) as a qualitative portfolio of evidence. This study further links to the Joint Learning activities in the first phase of the ACEWATER I, to show relevance and attribution to some of the HCD and Research activities of ACEWATER II.

The benefits derived from the ACEWATER project will focus on five dimensions which include benefits attributed to knowledge production, policy development, economic-, social- and ecological impacts. It is acknowledged that the five dimensions are interconnected, and would include for example socio-economic, and socio-ecological dimensions. In addition, pathways to impact are identified, from which lessons can be learnt for future phases of the ACEWATER project.

When considering the impact of a programme or project, various aspects need to be taken into account and include (note that these aspects will further be elaborated upon in the theoretical framework in Annexure B):

- What is meant by the term 'impact'? In this study, the Payback-PLUS Framework is presented to demonstrate various aspects of impact, including knowledge, policy, social, economic and ecological impact. Indeed, the various aspects of impact cannot be viewed in isolation where, for example, the interlinked nature of socio-economic impacts and socio-ecological impacts needs to be considered.

- What is meant by, and what is the importance of, attribution? In measuring the benefit of scientific research, or in the case of the ACEWATER project, the question will always be asked whether the outputs are really the key driver for the eventual impact, referred to as attribution (Boaz et al., 2009c; Hargreaves, 2009; Molas-Gallart et al., 2002; Molas-Gallart & Tang, 2011). This has led to some studies tending to use language that focuses on the influence of research rather than impact (Boaz et al., 2009c). Researchers such as Buxton (Buxton, 2011) affirm that “any impact is the product of the whole R&D system and not exclusively produced by the original researcher” (Buxton, 2011) (p. 260) or that impact could be made through a series of “productive interactions” (Spaapen & van Drooge, 2011a)

- What is meant by, and what is the importance of, additionality? Aspects related to additionality also need to be considered within the ACEWATER project, and how does the contribution this project has made to impact, relate to those of other
projects (H. Davies et al., 2005b), and would the same benefits be achieved without the research programme (Klautzer et al., 2011).

- A challenge exists whereby the ability to quantify and establish attribution reduces over time (Boaz et al., 2009c). When research findings are published as outputs in the form of reports and/or articles; initial, intermediate and final outcomes can take quite a while to occur, resulting in a decrease in the ability to track attribution over time. An opportunity presents itself in this project to identify outputs from ACEWATER phases I and II and to identify and report on the extent such outputs have contributed to impacts.

- The timing of study – As mentioned earlier, the ACEWATER project spans a period from 2010 to 2021. Research impact assessments can be conducted either ex-ante (i.e. before the research) to assess the potential significance and used to evaluate what the R&D project aims to do, or ex-post (i.e. once the research has been completed) to measure the eventual outcomes and performance of the project (Bulathsinhala, 2014). Literature tends to focus on ex-post evaluation (Chiesa et al., 2009; Kimura, 2010; Lee et al., 1996; Sakakibara, 1997) of projects, or ex-post evaluation at the programme level (Arnold et al., 2005; Blumstein, 2010; Georghiou & Roessner, 2000; Hobday, 1988; Ormala & Vonortas, 2005).

This study will be undertaken as an ex-post view of the two phases of the ACEWATER project’s duration. It does, however, provide an opportunity to set a basis and framework for the continued identification, monitoring and reporting outcomes and eventual impact, for further phases of the ACEWATER project. Here, this study can inform and can be carried forward and integrated into any and all future ACEWATER activities, thus providing an opportunity for the ex-ante framework on the significance of such a project.
Chapter 3: Methodology

As a framework for the study, the Payback-PLUS framework was used (Refer to Annexure B for detail). In terms of data collection, a mixed-methods approach was used, which included surveys and interviews, and the collection of qualitative and quantitative data. The results of the study is presented as a portfolio of evidence in Chapter 5.

Considering that the ACEWATER II project consisted of a Human Capacity Development component and a transboundary river basin research component which did not conclude as the same time, two approaches were followed:

- For the Human Capacity Development component of the ACEWATER II project, project reports were assessed to identify the benefits. In addition, project workshops in February 2020 in Dakar, Senegal and Addis Ababa, Ethiopia were used to workshop activities from where impacts were identified at a country level. This stage was closely supported by the project coordinator at UNESCO, which further assisted in identifying benefits from the activities.

- For the research activities, the outputs from the ACEWATER II project were identified, which is based on the Terms of Reference and also the project implementation documentation available from the EC JRC who managed this aspect of the project. In addition, the contact information for the project implementers was accessed from the EC JRC. This documentation and contact information formed the basis for custom communications with stakeholders who participated in the research activities, and where relevant, other stakeholders were contacted emanating from the survey and interviews. These contacts were used to ensure that the benefit can be attributed to the specific research activities to be investigated.

Through a custom communication in June/July 2022, which addressed the participant in person and also reminded them of the specific outputs they were responsible for or involved in, 45 stakeholders involved in the transboundary water research activities were contacted. These stakeholders were requested to complete an online survey which probed their feedback on benefits based on the five impact dimensions. The survey was translated from English to French and disseminated to the relevant stakeholders. In total, 21 responses were received to the survey, with 4 interviews conducted. It should be noted that in some cases, the participants form the secretariats, who had and overall view of the project, made contributions either through interviews or through this written report.
The feedback from both activities are reported upon in this document.
Chapter 4: Setting the scene: Framing the deliverables and impact of the ACEWATER activities

As indicated earlier, the research and capacity development activities in the ACEWATER II projects were designed to build on the joint learning and knowledge management activities from ACEWATER I. In the early years of the ACEWATER project (in the late 2010s), the focus was primarily on Joint Learning and the establishment of two initial networks in Southern (SANWATCE) and Western Africa (WANWATCE), with an Eastern/Central Africa network (CEANWATCE) established as part of the ACEWATER II stage around 2016. Joint Learning activities included the joint organisation of workshops to discuss regional priorities in terms of water and sanitation and the contribution research could make towards policy-making. Subsequently, all project reports were made part of the Aquaknow Knowledge Management Platform hosted by the EC JRC.

The aim was that the activities would form the basis for these networks to collaborate and engage with their different regions to fulfil its mandate to support policy decisions through transboundary research activities and addressing water sector skills gaps through Human Capacity Development.

4.1 Supporting policy decisions through transboundary river basin research

In the Southern African Region, the member institutions of the AUDA-NEPAD SANWATCE chose the Zambezi Basin to undertake various research activities and thus contribute towards a scientific impact through knowledge production and capacity development. In addition, since the Zambezi Watercourse Commission (ZAMCOM) has a well-defined Strategic Plan, it was decided to identify specific focus areas within the Strategic Plan, to which research and capacity development initiatives could be targeted in order to make the largest contribution.

Through a consultative process, researchers from the AUDA-NEPAD SANWATCE, with the support from the EC Joint Research Centre, engaged with relevant officials from ZAMCOM to identify specific areas of collaboration. In addition, each AUDA-NEPAD CoE engaged, from the outset, with various external stakeholders such as National Meteorological Services, National Water Authorities, Geological Services Agencies to access relevant data, which would eventually feed data to and from the ZAMCOM Management Information System.

As in the case of the SANWATCE network, network members in the Western African Network of AUDA-NEPAD Water CoEs, (WANWATCE) have long-standing relationships with River
Basin Organisations and Research Centres in their Region, such as OMVS and other regional bodies such as AGRHYMET.

Although a specific consultative action did not take place to identify specific needs based on strategic plans at the RBO, various interactions beyond the ACEWATER project with the RBOs and entities such as AGRHYMET, contributed towards activities that complimented the RBOs. This is an example of attribution of activities beyond the ACEWATER project that influenced the impact of the ACEWATER project. Moreover, the active participation of AGRHYMET in the project ensured that specific strategic needs were identified.

Member institutions in the Central/Eastern African Network of Water CoEs (CEANWATCE) primarily focussed the research activities in the Nile River Basin and the Lake Victoria Basin. As in the case of WANWATCE, a specific consultative action was not undertaken to engage with the different RBOs, but due to the long-standing research relationships institutions have in the region with the RBOs and the involvement of the General Secretary of the Nile Basin Initiative during the ACEWATER project workshops, deliverables were in line with the needs of the region. An example of such is the identification of key issues related to the assessment of energy production and impacts of downstream water flow and the related impact on agriculture resulting from the GERD (Grand Ethiopian Renaissance Dam), which were top of the agenda. Here, deliverables supported such key issues for decision making.

Deliverables from these research activities contributed towards knowledge production, as highlighted in the following chapter.

In addition to the research activities undertaken by the various member institutions of the AUDA-NEPAD Networks of Water CoEs, assessments of the water sector skills gaps in various regions were undertaken, which will be discussed in the following section.

4.2 Addressing water sector skills gaps through Human Capacity Development

For each country, the in-country AUDA-NEPAD Water CoEs undertook a desk-top study to analyse the water sector to determine the status quo of in-country HCD activities, and the identification of various stakeholders in the countries’ water sectors. The desktop-study was followed by a series of consultation and validation workshops with stakeholders in each country to identify needs, from where National Frameworks (or contributions to existing strategies) could be developed. It should be noted that the process differed in some countries, and guided by in-country factors such as national directives on who should develop National Frameworks and the status of existing water sector HCD Frameworks and Strategies. For example, in Mozambique, the process of developing a National water sector HCD Framework was initiated
by the Ministry of Science and Technology with interventions from IWEGA at Universidade Eduardo Mondlane and in South Africa, various activities have been underway which address national water-sector HCD needs, with major involvement by the Ministry of Water and Sanitation. In East and West Africa, the role of national ministries also differed, which will be highlighted in specific cases in the following sections. For each country, national priorities were identified which relate to Young Professionals and Technical Vocational Education level (TVET), and validated at a regional level through a series of regional stakeholder workshops were held in late 2019 and early 2020 in each of the three regions, to present findings from activities. These regional meetings were attended by members from all the AUDANEPAD Water CoEs, other capacity development role-players in the regions, and relevant representatives from the different RECs.

It should be noted at this stage that academics are not always primarily involved in driving policy-making processes. In developing inputs into National water sector HCD Framework within the ACEWATER II project, some academics confirmed during the SANWATCE regional meetings that they initially felt ‘out of their comfort zones’ while engaging with policy-makers. However, it was found that the activity had a positive impact in that through the processes, individual and organisations growth took place, especially when the outputs were valorised, and academics experienced that their inputs were accepted.

To further contribute towards National water sector HCD Frameworks, pilot courses were identified to address in-country needs. All CoEs planned to conduct on-site training as part of the HCD component of the ACEWATER project, however, due to the outbreak of the Covid-19 pandemic, initial pilot courses could only be presented in Sudan and Ethiopia before all universities were affected by lockdown regulations. Subsequently, where feasible, pilot training courses were planned to be presented online as part of a re-alignment of project activities by UNESCO-IHP.

To further frame the skills development activities, details are provided at a national level:

- In a case study of Nigeria (a network member in the WANWATCE), the National Water Resource Institute (NWRI) in Kaduna identified that a shortage of skilled human resources was a major challenge, and further identified a spectrum of training needs in various water resources sub-sectors. The training needs were identified at Federal, State, and Local Government Agency (LGA) levels in Nigeria. The method used for the study included reporting on the background and overview of water sector HCD in Nigeria, preparing preparatory meetings, the development, and administration of a structured questionnaire, with the results of the survey documented.
Through the stakeholder engagement, various actors at State- LGA- and Community levels were identified and guided the development of customized training. For example, Borehole Geophysical Logging training was identified as a need amongst Water Supply Officers at State level, and Pump Installation and Maintenance training was identified amongst Water Supply Officers and Hand Pump Mechanics at State Level, amongst Water Supply Officers and Mechanics at LGA level and among Community Water Point Caretakers. Non-technical needs such as Human Resources Development Planning and Strategies and Training Managers were also identified.

As part of the Implementation plan, various priority courses were identified and implemented. These training courses are reported upon in the following chapter knowledge benefits.

- For the water sector in Senegal, the Cheikh Anta Diop University undertook a national assessment of the water sector with stakeholders such as the Senegal Ministry of Water with, as part of the national assessment, a survey indicated that a lack of qualified human resources (63%), followed by insufficient equipment (52%) and lastly (16%) a lack of financial resources contribute towards to ineffective execution of tasks in the water sector. It was evident that training and capacity development needs were principally in project planning, management, and monitoring; project design; financing research and the development of institutional and regulatory frameworks. In addition, the sector assessment indicated that there are various academic and polytechnic institutions with professional and private institutions supporting research and capacity development in Senegal. The results of the above study also showed that various courses needed to be developed to support capacity development aimed at technical/senior professionals and in addition, young professionals. These courses include project management (design, planning monitoring and evaluation, fundraising, and the development of institutional and courses in regulatory frameworks for technicians and senior professionals. In addition, the new courses incorporate GIS and remote sensing technologies and hydrological modelling (including SWAT, Mike 11, Gr4J, TopModel, WEAP).

- In Ghana, the Kwame Nkrumah University of Science and Technology (KNUST), undertook the activity to develop a Ghana National HCD Framework as a member of AUDA-NEPAD WANWATCE. Through the national assessment of the Ghanaian water sector with capacity and skills gaps identified for young professionals and technicians, in four sub-sectors of the Ghana water sector. These sub-sectors include water resources management; water supply management; environmental sanitation management and lastly environmental health and hygiene.
In Sudan, the Water Research Centre (WRC) at the University of Khartoum water sector assessment targeted specifically at Ministry of Water Resources, Irrigation and Electricity and its various Divisions, Universities and Research Institutes in the country, UN organizations, NGO’s working in the water sector Sudan, and the Private Sector. From the sector-wide assessment, various urgent training needs were identified and categorized into six main themes. These themes are 1) Water Supply and Sanitation, 2) Irrigation Management, 3) Surface Water Hydrology, 4) Groundwater Sustainable Management, 5) Integrated Water Resources Management, and 6) Data Acquisition and Management Tools.

The Ethiopian Institute of Water Resources (EIWR) at Addis Ababa University identified HCD gaps and training needs relating to operational hydrology; surface water resources assessment using advanced modelling techniques; irrigation system diagnosis, on-farm water management and operation management; water productivity and irrigation systems modelling. Courses to address these needs were planned to be synchronized and linked to existing training courses at the EIWR. Aimed at technicians at TVET level, two training courses were conducted in January 2020 on Operational Hydrology: Flow and Sediment Monitoring in Streams and Irrigation System Diagnosis, On-farm water management, and Operation and maintenance. Participants were from 6 public institutions: the Basins Development Authority, the Irrigation Development Commission, the Awash Basin Development Office, the Abay Basin Development Office, the Rift-valley Lake Basin Development Office, and the Ethiopian Water Technology Institute. In addition, two HE level Professional training courses were conducted in February 2020, with participants being staff and MSc and PhD students from the Addis Ababa Institute of Technology (AAiT), the Ethiopian Institute of Architecture, Building Construction and City Development (EiABC), and the EIWR, the Ethiopian Irrigation Development Commission, Basins Development Authority and Basins Development Offices.

In Uganda, the Makerere University has a long-standing and very productive relationship with the Ugandan Ministry of Water, and in partnership with various stakeholders from the sector were engaged to identify priority areas for capacity development. Key to the HCD activities in Uganda is the relationship between Makerere University and the Ugandan Ministry of Water which played an instrumental role in reviewing and finalizing the pilot courses designed to address the water sector HCD priorities, the selection of participants,
and the procurement of training consultants. The priority areas are 1) The preparation of bankable project proposals, 2) Negotiation and Water Diplomacy, 3) Borehole Drilling and Pump testing Supervision and 4) the Design, Construction and Operation & Maintenance of Solar Water Pumping Systems.

- In Botswana, a National Human Resource Development (HRD) Strategy exists, however, the Strategy is not specific to the water sector and does not address junior professionals and technical level actors. Through a national consultation dialogue, other shortcomings were identified in the HRD Strategy, including inadequate policy and legal instruments, inadequate water-related courses offered for TVET and the limited involvement of youth in strategy development. In order to make a niche contribution, the HCD gaps and needs specific to the water sector, and in particular, for Junior Professionals and Technical level actors, was addressed through a sector-wide analysis. The Botswana Human Resources Development Council (HRDC) was targeted to address the ACEWATER HCD inputs, given their mandate for policy advice on all matters of national human resource development, and to coordinate and promote the implementation of the National HRD Strategy. As part of the national assessment, key institutions were identified as stakeholders for collaboration and consultation in drafting proposals for water sector HCD needs and priorities to present to the HRDC. The institutions include the Botswana Qualifications Authority (BQA), Department of Water and Sanitation, Water Utilities Corporation, Tertiary institutions and Technical Colleges. These institutions were consulted in a validation workshop.

From the scoping study and through the stakeholder engagement, certain priory needs were identified. In Botswana, training in isotope hydrology and integrated groundwater-surface water hydrology is a priority for young professionals, with training needs in borehole drilling and well maintenance and groundwater monitoring and analysis priorities for at a TVET level. As a result of the sector-wide assessment, pilot courses have been developed to address the needs of the Botswana water sector at both a professional and technical level. For professional training, two courses in advanced hydrology and training in water resource management were identified. The technical level training, a further two courses in applied and field hydrology for practitioners and principles of hydrology for technicians were identified.

- In Mozambique, the process of developing a National water sector HCD Framework was mainly initiated by the Ministry of Science and Technology as this is required by national directives. As part of the ACEWATER II project, IWEGA at Universidade Eduardo
Mondlane undertook the desk-top study in investigating the *status quo* of HCD activities in the Mozambican water sector, and further supporting the Ministry of Science and Technology in the process to identify sector skills needs and undertake consultative workshops while focussing on Southern and Northern Mozambique.

From the national assessment, it became evident that priority areas for young professionals are in water quality management, water economics, and governance and integrated water resources management. In addition, skills development needs were identified in the monitoring and evaluation of water quality and design and assembly of different water supply systems at a TVET level. This resulted in two courses identified a graduate training and are 1) Management and maintenance of networks and water losses and 2) Community education. For technical training, two courses were identified namely 1) Environmental Impact Assessment and 2) Water quality assessment.

- The sector-wide assessment undertaken by the University of Malawi confirmed that water sector skills gaps are in-line with current HCD needs identified by the Malawi Government, with capacity gaps mainly for water engineers, water law and policy experts, in communication skills, project management, data managers, social scientists, surveyors, extension workers and water researchers. Through consultative meetings with Government Ministries, Water Boards and NGOs, two courses were proposed to address professional level training namely 1) Water quality modelling and 2) Hydrological modelling. In addition, two courses were identified aimed at technical level training, namely 1) Water supply and 2) Water and sanitation technology. These courses would address training in the principles of hydrology, hydrological modelling, and water supply was identified as priority areas for young professionals, and a certificate program for water technicians and an apprentice diploma for water technicians were identified as a priority at a TVET level.

- In Zambia, the national assessment of the water sector identified the need to establish an activation of the water trust to finance capacity development at the different educational levels. Short term courses presented over a few days or a few weeks depending on the content, were regarded as an immediate intervention that would support changes in the mandate of the Zambia Ministry of Water. In addition, a need was identified to develop a training plan as a document to direct potential funders and uphold priorities for capacity enhancement and a need to explore mechanisms in which prior learning would be recognized as a formal qualification for example drillers. The consultative process further highlighted a need for internships which should be supported to allow graduates to acquire
some industrial experience was also a priority. The national dialogue was supported by various role-players such as the Ministry of Water Development, Sanitation and Environmental Protection, the National Resources Development College (NRDC or NORTEC) and representatives from TVET colleagues and other Higher Education institutions. To address skills gaps, a course in Water resources monitoring and a course in Environmental quality modelling were identified to address the needs of young professionals. To address technical needs, a course in Field hydrogeology and a course in Drilling methods and training related to well completion were identified.

• In South Africa, various initiatives are currently underway to address HCD needs in the national water sector, with the FETWater program one of the major initiatives, being implemented by the National Department of Water and Sanitation (refer to http://fetwater.co.za/ for more detail). The FETWater program objective is to ‘Develop a competent person’, and follows an occupational-oriented approach where the traditional academic training is encouraged to match the occupational training to ensure that the knowledge, practical skills, and work-based modules are aligned and a competent person is produced who will be relevant to the prevailing and upcoming market to do the actual work.

In addition, South Africa has a new Water and Sanitation Master Plan (2018), addressing various HCD needs and related programs. There are also numerous capacity building institutions, water utilities, and government department which offer a variety of HCD initiatives. There is, however, a need for a Monitoring, Evaluation, and Reporting (MER) Framework for the different initiatives at a national level, which was confirmed during a validation workshop with various stakeholders in September 2019. During the National Validation Workshop, key stakeholders agreed that an MER Framework should be developed, and inputs were given on the elements, indicators, usefulness, ownership, and funding of the proposed MER plan. It was further agreed that the MER framework should be commissioned, supported and owned, by the Department of Water and Sanitation (DWS) as the sector leader while the Department of Higher Education and Training (DHET), through Sector Education and Training Authority (SETA) - such as Energy and Water and Local Government SETAs should co-fund the process.

The activities as discussed in the section above, contributed towards impacts (or benefits), which will be highlighted in the following chapter.
Chapter 5: Results. Benefits associated with the ACEWATER project

In considering the impact of the activities in the ACEWATER II project, it is worth noting that the member institutions in the AUDA-NEPAD networks of Water CoEs are universities and research institutions, and at the core of their mandates are capacity development and research. The question can be asked ‘for what purpose or for whose benefit?’, and at the heart of this answer lies society - universities and research institutions who undertake research and capacity development in the service to society. While the primary objectives of universities may not necessarily influence policy, their core business of knowledge production and capacity development can drive innovation, and can influence decision-making which in turn lead to benefits to society, the economy and the ecological environment.

The following chapter highlight the contribution the activities in the ACEWATER project made to knowledge production, policy making and also socio-, economical and the ecological environment as presented in a portfolio of evidence. This evidence has been captured through the assessment of project reports, online surveys and interviews with stakeholders which participated in the ACEWATER project. One should also consider that this portfolio of evidence is indicative at the time this study was undertaken, and that some of the benefits will only materialise over time in future. To address this, pathways to impact are also identified in the following chapter.

In addition, the chapter starts with discussing the contribution the AUDA-NEPAD Networks of Water CoEs have made towards creating an enabling environment and joint learning, which provides a basis for the longer-term sustainment of the initiative. Many role-players have contributed towards these benefits and where relevant, the contribution of the EC-supported ACEWATER project is highlighted.

5.1 An enabling environment - Cooperation with continental and regional bodies

Since the inception of the ACEWATER project in the mid-2000s, a principle was established whereby the CoEs not only function as an academic network but that they would also partner and collaborate with regional and continental agencies and other research and capacity development networks in the water and related sectors. Given that the AUDA-NEPAD CoEs have their origin in the African Union, and specifically AMCOW and AMCOST, the secretariats of the AUDA-NEPAD Networks of Water CoEs, SANWATCE, WANWATCE, and CEANWATCE are regularly invited to participate in AMCOW meetings to update ministers on activities of the AUDA-NEPAD CoEs. Since the inception of the AUDA-NEPAD Networks of
Water CoEs in 2006 when AMCOW and AMCOST established the programme, activities are framed by AMCOW Decisions, and specifically two decisions in 2013 and 2018/2019:

- In 2013, the AMCOW General Assembly approved the decision for the AU/NEPAD Centres of Excellence “to develop a Human Capacity Development Program aimed at addressing junior professional and technician level capacity challenges in the water sector”. This is based on a Decision taken during the 11th General Assembly of AMCOW in 2013 (Decision: EXCO/11/2013/CAIRO/17) (Decisions of the 11th AMCOW Executive Committee of the African Ministers Council on Water (AMCOW) on 6th June 2013 in Cairo, Egypt, 2013).

- In 2018/2019, the AMCOW General Assembly Council further approved Decision GA/11/2018/LBV/7 (Decisions of the AMCOW Executive Committee of the African Ministers Council on Water (AMCOW) taken in Libreville, Gabon (2018) and Cape Town, South Africa (2019), 2019) which “directs the [AMCOW] Secretariat to work with the AUC and NEPAD Centres of Excellence to support the understanding of patterns of knowledge and skills demand and migration in order to both strengthen the resilience of Africa’s Water Resources Sector at a national and transboundary level and promote Youth Employment.”

In addition to the African Union, the partnership with the European Commission (EC) through the Joint Research Centre (EC-JRC) is worth noting. Since the initial establishment of the (then) NEPAD Networks of Water CoEs in 2006, the EC-JRC actively support the CoEs through the ACEWATER I and ACEWATER II project. Over time, cooperation has evolved to the collective conceptualisation, project proposal and eventual support of research and HCD activities in the ACEWATER II project by the EC. Moreover, the EC-JRC facilitated the partnership between the AUDA-NEPAD Water CoEs and UNESCO-IHP in the ACEWATER II project, whereby the HCD component of the project is channelled through UNESCO-IHP.

At a regional level, such partnerships and collaborations continued throughout the life of the ACEWATER project, often resulting in formal Memoranda of Understanding (MoUs), which would have a positive contribution to the various impact-dimensions. Examples and evidence of such cooperation and agreements are as follows:

- In the West-African Region, the CoEs in WANWATCE entered into a MoU with the Economic Community of West African States (ECOWAS) during the ACEWATER I, with the objective to seek opportunities to strengthen research and capacity development cooperation. There is a need to further support the intended activities in the MoU and to support the institutionalisation of the agreement.
• Apart from the MoU with ECOWAS, AGHRYMET and the Niger Basin Authority (NBA) both entered into partnerships with AUDA-NEPAD CoEs in the WANWATCE during ACEWATER II, to collaborate in various research, policy and capacity development initiatives. AGHRYMET is a Regional Centre established in the mid-1970s as a specialized institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). The CILSS comprise of various member states in West-Africa and includes Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal. Similarly, the NBA is a West-African intergovernmental organisation with member countries which include Benin, Burkina Faso, Cameroon, Côte d’Ivoire, Guinea, Mali, Niger, Nigeria and Chad which aim to promote cooperation amongst the member states. Through activities during ACEWATER II, such as regional stakeholder meetings to identify the Human Capacity Development needs and skills gaps, both AGHRYMET and the NBA committed their organisations to establish formal Memoranda of Understanding with the West African Region CoEs for research and capacity development activities in support of the ACEWATER II Project and beyond.

• Another example of AUDA-NEPAD Water CoEs cooperation with an agency facilitated by the ACEWATER II project, is the involvement of the Université Cheikh Anta Diop de Dakar (UCAD) as the secretariat of the AUDA-NEPAD WANWATCE, participating in the Priority Pilot Groups and Priority Action Groups related to Water Security, Sanitation and Cooperation of the 2021 World Water Forum. (World Water Council, 2019)

• In East Africa, an AMCOW representative from the regional body, the East African Community (EAC), actively participated in the application, evaluation and recommendation of members of the AUDA-NEPAD CEANWATCE in 2016. In addition, the cooperation from the EAC regularly translates into regional meetings.

• In the Southern African Region, the AUDA-NEPAD SANWATCE secretariat regularly participates in meetings of the SADC ministers of Water (through the Water Resource Technical Committee – WRTC) and the SADC ministers of Science and Technology. This culminated in a decision in 2013 whereby the SADC Ministers of Water approved the AUDA-NEPAD SANWATCE business plan and activities of the AUDA-NEPAD SANWATCE. The AUDA-NEPAD SANWATCE secretariat regularly reports to the SADC ministers of Science and Technology, where activities are formally noted by ministers, thus providing input into policy formulation.

• In addition, the AUDA-NEPAD SANWATCE has made significant contributions by partnering with key regional role-players such as the Southern African Development Community (SADC) Water Desk, WaterNet, the SADC Groundwater Management
Institute (SADC-GMI) and the Zambezi Watercourse Commission (ZAMCOM). Based in the SADC headquarters in Gaborone, Botswana, the SADC Water Desk is responsible to oversee and facility regional instruments for water cooperation and include the Regional Water Policy, the Regional Water Strategy and the Regional Strategic Action Plan on Integrated Water Resources and Development Management (RSAP) which was introduced in August 1998 to run in five-year phases. Eleven members of the AUDA-NEPAD SANWATCE actively participate in contributing towards the RSAP and were instrumental in establishing the SADC Water Science Research Agenda. The involvement of AUDA-NEPAD SANWATCE member institutions in the development of the SADC Water Science Research Agenda was an indirect consequence of the ACEWATER II project.

- To further address research and capacity development in the SADC region, the AUDA-NEPAD SANWATCE has concluded formal MoUs between the Zambezi Watercourse Commission, WaterNet and SADC GMI, the latter two also being formal implementing agencies of the SADC Regional Economic Community.

- The AUDA-NEPAD SANWATCE further has a long-standing arrangement with the South African Department of Science and Innovation and the South African National Research Foundation for the direct financial support for activities through the Secretariat hosted at Stellenbosch University – this agreement has been in place since 2009, whereby the national agency support research grants and secretariat activities on an ongoing basis.

From the above section, it is evident that the AUDA-NEPAD Networks of Water CoEs have sought and established cooperation with continental and regional agencies and in cases, resulting in formal ministerial decisions and bilateral MoUs to undertake research and capacity development activities. These decisions and agreements can be attributed to being a pathway to impact and being leveraged to seek support and initiate projects such in the case of ACEWATER II, which led to research and HCD activities in West, East and Southern Africa.

5.2 Joint learning

Since the inception of the ACEWATER project in the mid-2000s, an important aspect of establishing Networks of Water Centres of Excellence was to create capacity in the Centres of Excellence (CoEs) to address African water- and sanitation-related issues. This was done with a specific Joint-Learning activity which also contributed greatly to building the identity of the Network. This aspect was highlighted as a key component in the early stages of the ACEWATER project (2011 to 2013) and included activities such as a series of workshops and
seminars to raise awareness on a Sector Wide Approach. The seminars and workshops were jointly conceptualized based on regional needs, designed with surveys to determine thematic needs, with results of the workshops and seminars analysed and reported. These activities had an organizational impact with the members of the network gaining experience and building confidence in collaborating with each other in some cases for the first time. The Central East African Network of Water CoEs (CEANWATCE) was established in the second phase of the ACEWATER project in 2016. Their research tasks included Human Capacity Development (HCD) activities, and also served to contribute to the Centres of Excellence universities to build a network in this region; nurturing collaborative skills and which contribute towards the broader aspect of Joint-Learning already underway with CoEs in the other regions of Africa.

Part of the governance of the AUDA-NEPAD Networks of Water CoEs is the establishment of secretariats for each network. In SANWATCE, the secretariat is hosted at the Stellenbosch University (South Africa), for WANWATCE, the secretariat is hosted at the Université Cheikh Anta Diop de Dakar (Sénégal) and for CEANWATCE, the secretariat is hosted at the University of Khartoum (Sudan). These secretariats regularly communicate and coordinate activities amongst network members. In SANWATCE, an annual Steering Committee meeting is organized back-to-back to the WaterNet/WARFSA/GWP symposium. In the case of WANWATCE and CEANWATCE, annual project meetings are an integral part of the ACEWATER activities, which result in network members physically meeting at least once a year. Such Steering committee meetings and annual project meetings present the opportunity for network members to discuss and report on collaboration activities, thus contributing to the aspect of Joint-Learning and collaboration.

By continuously collaborating under the auspices of the AUDA-NEPAD Networks of Water CoEs, members of (at least) the SANWATCE have reported during annual Steering Committee meetings that institutional research capacity has increased among the university network members, which resulted in direct benefits to knowledge production. Such increased research capacity and joint learning have resulted in new collaborative research projects, an increase in joint publications, joint supervision of post-graduate students, and increased staff and student mobility amongst member institutions. Such joint collaborations have extended to other programmes such as SASSCAL (Southern African Science Service Centre for Climate Change and Adaptive Land Management), WASSCAL (Western African Science Service Centre for Climate Change and Adaptive Land Management), WaterNet and the Pan African University.

Joint Learning activities further extended to collaborative participation of AUDA-NEPAD Water CoEs in project conceptualisation and project development during initial stages of the ACEATER II project. Moreover, through well-established partnerships with key-stakeholders
at a continental and regional level, other key stakeholders could also be consulted during the project proposal stages. Evidence, such as letters of support from AMCOW, the secretariats of the AUDA-NEPAD CoEs and the African Network of Basin Organisations (ANBO), confirm that the European Commission Joint Research Centre (EC-JRC) actively engaged with members of the AUDA-NEPAD CoEs and key-stakeholders in the design and development of the proposal of the ACEWATER II project, following the AMCOW Declaration in 2013 (refer to section 3.2 for more detail on the AMCOW Declaration). The collective participation of AUDA-NEPAD CoEs where not limited to the ACEWATER project, and CoEs regularly participate in projects in SASSCAL, WASSCAL and WaterNet, as reported during annual Steering Committee meetings.

In terms of policy formulation, joint-learning activities have contributed to policy formulation where, for example in the research and HCD activities in the ACEWATER II project (refer to sections 5.3 and 5.4). For example, in the case of the HCD activities of ACEWATER II, CoEs made specific contributions to national HCD Frameworks. Moreover, CoEs have reported that by continuously involving other CoEs in the various activities, best practices could be shared which strengthened CoEs.

5.3 Knowledge Benefits

Considering the recent conclusion of the project, identifying contributions to the body of knowledge was relatively easy. From a scientific perspective, a range of research outputs was produced as part of the ACEWATER 2 project and include a total of 141 outputs as reported in the final report of the ACEWATER 2 project (Ronco et al., 2021). Research outputs include scientific deliverables such as project reports highlighting technical aspects such as hydrological models, guidelines for case studies, hydrology, hydropower and climate change scenarios, Water-Energy-Food-Ecosystem nexus assessments and databases and models which provide a concrete base for further research to be undertaken. These deliverables were produced for both scientific and Human Capacity Development (HCD) activities of the ACEWATER 2 project. It will not be pre-emptive at this stage, to mention that the high volume of knowledge products in the ACEWATER project has elevated the reputation of many members of the AUDA-NEPAD Water CoEs and their institutions in their countries and also region, working closely with ministries and other stakeholders to influence decision making – here, examples will be highlighted below.

Based on the expertise within each AUDA-NEPAD SANWATCE CoE, examples of contribution include:
• The characterization of the groundwater hydrology in Zimbabwe of the Zambezi River Basin by the National University of Science and Technology (NUST) in Zimbabwe. The activity focused on the following specific objectives:
  o To provide a multi-scale groundwater hydrology baseline database at ZRB and selected countries level, based on literature review, available data sources and existing country/regional scale studies of major relevance to WEFE nexus;
  o To provide baseline conditions database on groundwater hydrology and water demand vs. availability for few shared regional case studies, by gathering and processing data and by-products and to perform groundwater assessment;
  o To perform a vulnerability assessment to contamination of selected aquifers across the ZRB.

• The river basin scale groundwater hydrology characterization of the Zambezi River Basin (ZRB) conducted by the University of the Western Cape in South Africa. Here, specific objectives included:
  o A comprehensive spatial database of geology, aquifer and water quality
  o Maps (modified geology, lithology based aquifer, salinity & pollution, reserve and suitability ranking)
  o And estimation of groundwater reserve;

• The analysis of the groundwater hydrology and aquifers contamination relevant to WEFE Nexus analysis in Zambia, for the Zambezi River Basin by the University of Zambia. Here, specific objectives included:
  o To provide a multi-scale groundwater hydrology baseline database at ZRB and selected countries level, based on literature review, available data sources and existing country/regional scale studies of major relevance to WEFE nexus;
  o To provide baseline conditions database on groundwater hydrology and water demand vs. availability for few shared regional case studies, by gathering and processing data and by-products and to perform groundwater assessment;
  o To perform a vulnerability assessment to contamination of selected aquifers across the ZRB.

• The Climate Variability Assessment, with the objective to study how the Zambezi River Basin (ZRB) has been changing in terms of climate variability and extreme events, undertaken by the University of Botswana. Here, specific objectives included:
  o The evaluation of trends of climatic variables in the ZRB
  o The analysis of dryness/wetness conditions of the ZRB
  o The production of a dryness/wetness severity map for the ZRB based on the analysis
• The Hydrological modelling of the Zambezi River basin conducted by researchers from Stellenbosch University and Rhodes University (refer to Error! Reference source not found.. This culminated in a week-long training in Stellenbosch, South Africa, involving members from various member institutions, ZAMCOM, and the EC JRC.

• The effects of Climate Change on Hydropower Production Efficiency in Southern Africa undertaken by the International Center for Water Economics and Governance in Africa (IWEGA) at the Universidade Eduardo Mondlane, Mozambique. Here, the specific objectives included
  o The analysis of the trends of the main variables influencing water supply (flow in) and demand (flow out) in the Kafue, Kariba and Cahora Bassa reservoirs
  o Estimating the effects of climate change scenarios on hydropower profits
  o Estimating the effects of climate change on fish production profits and
  o Water Productivity in Sugar cane Agricultural Production in the Zambezi River Basin.

• The production of a project manual to for water governance, cooperation and information systems of the Zambezi Basin by the Council for Scientific and Industrial Research (CSIR) in South Africa;

• And finally, the University of Malawi undertook the characterization of current agriculture activities and potential future developments in irrigation in Zambezi River Basin (ZRB), with specific objectives as follows:
  o The characterization of current agriculture activities in the ZRB (crops, spatial distribution, productivity, irrigation vs. rainfed, including livestock and fisheries);
  o To understand baseline conditions in agriculture (including livestock and fisheries);
  o To assess crop water demand, productivity, and potential impact of irrigation expansion and scenario-based management practices.

Experts within the WANWATCE network produced the following deliverables (Ronco et al., 2021: p.29):

• UCAD, Senegal compiled a climate database which included both the Senegal and Gambia River Basins, to support climate assessment and variability analysis
- In the Niger Basin, AGRHYMET, Niger, applied the SWAT Hydrological model to the Niger River Basin to develop such a hydrological model for the basin
- The NWRI and the experts from Benin University in Nigeria, compiled a comprehensive overview of the WEFE nexus issues in the Northern (Sokoto-Rhima Basin) and in the Southern region which covered the Niger Delta. Overview of WEFE nexus issues could inform policy and decision-making in the region.

In Eastern/Central Africa, experts from the CEANWATCE network contributed towards the knowledge production through the following deliverables (Ronco et al., 2021: p.31)

- A spatial database on the water uses analysis in the lower Blue Nile Basin, downstream of the Great Ethiopian Renaissance Dam (GERD) by experts from the Water Research Centres (WRC) at Khartoum University, Sudan
- Experts form the Ethiopian Institute of Water Resources (EiWR) at Addis Ababa University (AAU), focussed on the upper Blue Nile Basin, also producing a spatial database on the hydrological and water uses analysis
- With a focus on the Lake Victoria basin, experts from Makerere University produced a spatial database on the hydrological and water uses analysis with experts from ICPAC, Kenya reported and produced a meteo-climate database, which supported the analysis activities of all CoEs which was complemented by a meteo-climate variability analysis of the Horn of Africa region and a hydrological assessment of the Lake Victoria basin.

In addition, related scientific activities were reported (Ronco et al., 2021: p.33) which include

- The identification of HCD water sector priorities and scientific key issues at a continental level
- The application of the Pitman/SPATSIM model to create a hydrological model of the Zambezi River Basin involving colleagues from Rhodes University, South Africa
- Hydropower modelling of major dams in the Zambezi river basin in collaboration with the University of South Florida, USA
- The status of geothermal energy in the Eastern. Southern Africa, long the Eastern Africa Rift System
- Scientific capacity was also developed through a training workshop at Stellenbosch University, South Africa in April 2019, which focused on the calibration and validation of the Pitman/SPATSIM Rainfall-runoff model for hydrological simulations.
• Contributions from activities resulted in the EC JRC creating a regional climatology database which was published on the online knowledge management platform, Aquaknow (https://aquaknow.jrc.ec.europa.eu)

The EC-JRC further produced the African Water Cooperation Atlas which included the dynamics related to the hydro-political risks in transboundary basins at a global level and then specifically at the African continental scale. The African Water Cooperation Atlas is available at https://aquaknow.jrc.ec.europa.eu/maptool/atlas

Apart from the research outputs produced as part of the deliverables in the ACEWATER II project, academics also reported other outputs such as research articles and other contributions.

Evidence to knowledge production is highlighted below:

• In Ethiopia, increased data regarding hydrology, water demand, water use, etc. were highlighted, which significantly assisted PhD researchers.

• Keeping to East Africa, on-the-ground implementation is seen in Kenya in the form of streamflow monitoring and a lake water level forecast system, which is the direct result of models developed under this ACEWATER phase. This development will be invaluable to riparian countries in flood forecast and water allocation.

• In Uganda, a forum of stakeholders including government officials and private sector specialists was formed which informed the priority areas and framework for HCD. Several training courses were consequently developed to better understand various water-related issues, which to date have unfortunately seen limited role-out. This phase also saw regional joint learning on the Lake Victoria and Nile basins with ICPAC in Kenya and Sudan.

• In West Africa, Nigeria reported knowledge gained which provided the impetus for an improved understanding of the Water, Energy, Food and Ecosystems (WEFE) nexus. This knowledge translated to published articles and further formalised in teaching curricula. In Senegal, several peer-reviewed articles were published, while a doctoral dissertation was formulated from this project, as part of a collaboration between UCAD (Senegal) and KNUST (Ghana).

• Southern Africa experienced the most widespread impacts. The study brought countries in the Zambezi basin riparian together, which resulted in at least four different peer-reviewed articles and several post-graduate students sponsored. In Malawi, these results including another article on the Lake Chilwa Basin led to a review of curricula, to better align with the current needs in irrigation and agricultural systems, while certain
decisions in government regarding water service delivery were also influenced by these findings. In South Africa, at least four journal articles were published. Greater awareness of the WEF nexus was created, while findings provided the basis for consequent funding proposals.

In terms of Human Capacity Development and identifying and addressing national skills gaps, the ACEWATER II project successfully supported CoEs at national level in identifying needs and defining priorities in the Water Sector with national governments.

- In Nigeria, the pilot courses will contribute towards knowledge production in the Nigerian water sector and contribute towards the NWRI’s reputation as a skills provider in the Nigerian water sector.

There is further evidence that the HCD activities in the ACEWATER II project have contributed to policy contributions and stimulated the National Technical Committee on Water Resources (NTCWR) to approve mandatory courses in the Nigerian water sector. In addition, NTCWR directed relevant government agencies to sponsor their staff for further training especially at the NWRI. The benefits of other training at the NWRI have been noted whereby follow-up assessments three months after the training indicated that some of the trainees that attended the NWRI training courses have benefited by way of promotion and financial socio-economic benefit through increased salaries. Although it is still too early to identify similar benefits from the ACEWATER II pilot courses, it is anticipated that similar assessments would reflect similar results.
In Ghana, the study resulted in the development and implementation of four courses in a Higher National Diploma (HND). The courses are 1) Water laboratory instrumentation, 2) Water systems instrumentation, 3) Sanitation technology and construction, 4) Borehole construction, and groundwater treatment. The courses are institutionalized and certified at the relevant National Board for Professional and Technician Examinations (NABPTEX).

In addition, four training courses were designed targeting young professionals which include 1) Waste resource recovery and entrepreneurship, 2) Onsite sanitation and faecal sludge management, 3) Water safety planning and management, and 4) Water Resources Modelling, IWRM & WEFE Nexus. In addition, two new MSc programs in Environmental Sanitation and also in Resource Recovery and Entrepreneurship are aimed at young professionals. Depending on the training course, KNUST would target professionals and technicians at government institutions and the private sector. All the pilot courses contribute to the Ghana National HCD Framework.
Following the validation workshop in Sudan, six training courses were identified, specifically aimed at young professionals and Technicians. At the time of reporting at the end of January 2020, three training courses were presented on Water, Sanitation and Hygiene (WASH), Data acquisition and Analysis in Water Management, and Data Acquisition in Surface and Groundwater.

In addition, the training courses contributed to knowledge production in the Sudanese water sector, with 96 young professionals participated in the training. The training courses further contribute towards the reputation of the WRC as a knowledge producer and skills developer in the Sudanese water sector. As a contribution to a social impact, there was a clear gender balance with 54% of the attendees being female. From the interviews and questionnaires with the stakeholders' institutions after the pilot courses, indications are that the training was useful in enhancing the abilities of their professionals and hence the role of the institution in the development of the water sector. The WRC further reported that the project created a good relationship with the stakeholder institutions which will enable the WRC to provide policy advice and also successfully carry out project activities in the future that serve the needs of these institutions.

A workshop in Sudan identifying skills needs which were opened by senior government officials indicating government support and valorisation of the process.

Students involved in skill training in Sudan. The training has increased their employability.
As in the case of other countries in the ACEWATER II project, the pilot courses in Ethiopia, will contribute towards knowledge production in the water sector and increase the reputation of the Ethiopian Institute of Water Resources (EIWR) at Addis Ababa University as a skills producer in Ethiopia. To further increase the potential for policy uptake, the National Human Capacity Development Framework prepared for Ethiopia has been disseminated to various main partners and stakeholders which include relevant government bodies, other higher education and research institutions, international implementing partners in the Ethiopian water sector, and private industry in the Ethiopian water sector.

It is evident that in Uganda, the training courses have contributed towards knowledge production in the Uganda water sector and, with the close partnership between the Makerere University and the Ugandan Ministry of Water, support for the HCD Framework pilot courses could result in further uptake of the pilot courses. By further playing a leading role in identifying water sector HCD needs in Uganda, a pathway to impact at an institutional level is created whereby the reputation of the Makerere University is developed as a water sector skills provider in Uganda. In addition, the close partnership between the education and government institutions ensured that relevant pilot courses were developed that address more closely the needs of the Ugandan water sector, and it is anticipated that this would increase the eventual impact of the pilot courses.

In Botswana, the three courses have contributed to knowledge production in the water sector, since the pilot courses were designed based on national needs. As indicated, the University of Botswana’s reputation as a knowledge producer and skills developer in the sector is further increased through HCD activities in the ACEWATER II project. Given the contribution of the University of Botswana and stakeholders into the HRDC,
policy impact is to be anticipated. Due to the Covid-19 pandemic, physical training could not be undertaken, with online teaching and learning planned.

- The training programmes have an impact on knowledge production at the Universidade Eduardo Mondlane and the Mozambican water sector, especially if the pilot courses are presented in future. In addition, the institutional reputation of the Universidade Eduardo Mondlane as a knowledge producer and skills developer in the Mozambican water sector is increased through the supporting role of the ministry in identifying HCD skills gaps in the country. It is anticipated that the leading role of the Ministry of Science and Technology would increase the potential for policy interventions, however, given the timing of this impact study directly, it is too early to find direct evidence of such policy interventions, with future monitoring required to report on such.

- As in other cases, the pilot courses will have an impact on knowledge production in the Malawian water sector and, given the process whereby key stakeholders were consulted in the ACEWATER II project, the reputation of the University of Malawi as a knowledge producer and skills developer in the Malawian water sector is further strengthened. Moreover, given the consultative workshops with key stakeholders in Government Ministries and Water Boards policy interventions could be anticipated. However, given the timing of this impact study directly, it is too early to identify direct evidence of such policy interventions at this stage.

- The training courses developed in Zambia, will contribute towards knowledge production in the Zambian water sector. In addition, during the national dialogue workshop, various key role-players were identified to address specific human capacity development activities in the Zambia water sector. This mapping of role-players will contribute towards decision-making and could have an impact in guiding policy interventions in future. As indicated earlier, the leading role the University of Zambia played in the sector-wide assessment to identify water sector HCD needs further adds to the reputation of the University of Zambia as a leading skills developer in the country.

- By involving key stakeholders in the process in South Africa, ownership of the Monitoring, Evaluation and Reporting (MER) Framework has been established with
the policy-making environment, and specifically in the South African Department of Water and Sanitation. This participation and ownership of the process at a policy-making level will increase the adoption of a MER Framework and was facilitated through the interventions of members in the AUDA-NEPAD SANWATCE. As indicated, the leading role CoEs played in interacting with key role-players in the South African Water sector, further increases the reputation of the AUDA-NEPAD Water CoEs as capacity and skills development institutions in the country.

5.4 Benefits to policy making

In certain cases, academics indicated that they are not aware if the research activities translated into policy. This is not unusual considering the recent conclusion of the project. What is however evident, is that academics are more certain of policy impacts in the HCD component of the project, where the project design included engagements with many stakeholders which included policy-makers to determine national HCD priorities. Such interactions assisted the uptake of research findings to be translated into policy and support from policy-makers.

- In Ethiopia, no direct policy changes were seen, however findings were used by hydrology and water resources engineering practitioners in the planning and design of water resources projects.
- Uganda saw engagement with stakeholders/ministry of water and environment, which laid the foundation for future policy discussions. Trainings were conducted which, along other engagements, addressed the issue of knowledge gaps. Moreover, the reputation of staff at Makerere University has increased which resulted in their participation in the development of a National Framework for Human Capacity.
- In West Africa, OMVS (Senegal River Basin Organisation) works in close collaboration with academia. ACEWATER 2 HCD and research findings were found useful to OMVS, which resulted in OMVS upgrading IWRM and manage water for its members.
- Malawi, Phase II of the ACEWATER project has contributed to policy development, and contributions to higher education. For example, sector-wide assessment confirmed the water sector skills gaps are in-line with current HCD needs identified by the Malawi Government. Capacity gaps include water engineers, water law and policy experts, in communication skills, project management, data managers, social scientists, surveyors, extension workers and water researchers.
- Also in Southern Africa, results from this phase in Botswana were adopted by national strategies such as the National Water Security Strategy. In addition, as a result of the ACEWATER project, Prof Piet Kenabatho from the University of Botswana as act as a
lead specialist in the Botswana Government, advising the Government on various aspects.

- In Namibia, with the Executive Committee of AMCow a key partner for the project, findings from the ACEWATER project were communicated with decision makers much more effectively. Furthermore, this project validated National Frameworks for human capacity building in the water sector with a focus on junior and senior professionals and technicians.

- In South Africa, there is currently significant interest in the Green Transition interventions with a strong emphasis on water and energy. The governance framework that was developed in the ACEWATER II project has significant resonance with potential implementation protocols, with some current projects being assessed in terms of their implementation approach against the framework.

### 5.5 Social-, economic- and ecological benefits

Different from knowledge contribution, evidence policy-, social-, economic- and ecological benefits take time to become clear and identifiable. For the ACEWATER project this is also true, and while there is some evidence of policy contributions as reported above, it is not surprising that social-, economic- and ecological benefits still need to realise in future. There are however some evidences already and reported as follows.

- Economic benefits across East, West and Southern Africa were largely in the form of personal employment, profile raising and promotion within their institutions.

- In Ethiopia, economic benefits were experienced at an individual level. One professor received a promotion after this project, while others’ prospects increased significantly.

- In West Africa, similar economic benefits were reported in Nigeria. While some staff were also promoted, a multiplier effect was seen in the form of knowledge gain, which led to a bigger knowledge base, teaching and research skills and ultimately, the economy. Prospects for personal promotion was also reported in Senegal.

- Similar economic benefits of employment, personal profile and promotion were experienced by Southern Africa countries. These countries include Malawi, Zimbabwe, Namibia, Botswana and South Africa. The latter also reported the subsidy benefits from publications.

- In Nigeria, ecological benefits include an improved understanding of the status (quality and quantity) of the basin area. Consequent models for predicting flows in the study area were developed. In Senegal, knowledge modelling iREFRAN and others on the sub-basin and Niger basin were produced in collaboration with AGRYMET. Results can
be applied to the management of water resources for different crops for example, to restore ecosystems, address invasive species. Furthermore, consultative workshops with stakeholders had a positive impact and formed the basis for buy-in stakeholders in the study design, input and dissemination. No doubt this will improve living standards of the inhabitants.

- In Senegal, with partners in a sugar company, the establishment of technical schools and programmes were pursued, which resulted in many exchanges trying to promote employment for the youth and young professionals in water and agriculture.
- In Nigeria, the training courses targeted were linked to Career Progression Courses for the water sector personnel which would provide a basis for future personal development and career advancement.

From the chapter, it is clear that the ACEWATER project has significantly contributed to the knowledge production which also targeted decision-makers, hence, significant evidence in these dimensions. Due to the relative recent conclusion of the ACEWATER II phase of the project, some evidence do exist of social-, economic- and ecological benefits, with evidence in these dimensions still to be realised and identified.

With this in mind, the following chapter will discuss the pathways identified which has the potential to support and realise benefits related to the ACEWATER project.
Chapter 6: Conclusions and recommendations

As evident in the previous chapter, significant evidence does exist of knowledge production with further evidence of policy contributions. There are pathways identified which could further contribute to such policy contributions, and which could also support the realisation of socio-economic benefits and also to the ecological environment.

This chapter explore these pathways to impact with further recommendations made.

6.1 Pathways to impact

In essence, the primary objective of the activities in the ACEWATER project was to undertake joint learning, knowledge management, support policy decisions through research and identify water sector skills needs and to further contribute towards the National water sector HCD Frameworks, through pilot training courses. These activities were not done in isolation and was benefited from Cooperation with Continental and Regional agencies.

- From the case studies related to Joint Learning and Cooperation with Continental and Regional agencies, the continuous involvement of all members of the AUDA-NEPAD Networks of Water CoEs in project activities and the governance of the networks, translate into the continuous learning whereby best-practices are shared and which impact on the general knowledge production amongst AUDA-NEPAD Water CoEs. Moreover, the cooperation with continental and regional agencies since the inception of the ACEWATER project in the mid-2000s, further contribute towards the participation of key stakeholders in consultative-, validation and regional workshops to identify research priorities and water sector skills needs. This participation impacted positively on undertaking relevant research activities and the eventual valorisation of the pilot courses.

- The continuous support of the ACEWATER Project of AUDA-NEPAD Networks of Water CoEs in continental and regional bodies and River Basin Authorities have further resulted in regular water-related dialogues on continental, regional and national water issues. Examples included the participation of network members in the annual WaterNet/WARFSA/GWP-SA Symposium in Southern Africa and the involvement of the Université Cheikh Anta Diop de Dakar (UCAD) as the secretariat of the AUDA-NEPAD WANWATCE, participating in the Priority Pilot Groups and Priority Action Groups related to Water Security, Sanitation and Cooperation of the 2022 World Water Forum. The participation of AUDA-NEPAD Water CoEs in such dialogues have
strengthened the reputation of the network members as water-sector knowledge and skills providers at continental, regional at respective national levels.

- Laying the foundation for future capacity development, the activities in the ACEWATER project supported formal Memoranda of Understanding concluded between the various organisations. In the case of West-Africa, a MoU exists between ECOWAS and members of the AUDA-NEPAD WANWATCE. In Southern Africa, the AUDA-NEPAD SANWATCE secretariat has MoUs with key regional role-players such as the Southern African Development Community (SADC) Water Desk, WaterNet, the SADC Groundwater Management Institute (SADC-GMI) and the Zambezi Watercourse Commission (ZAMCOM).

- The participation of AUDA-NEPAD Water CoE secretariats at continental and regional decision-making platforms such as AMCOW and SADC have contributed towards policy formulation, as evident by the declarations related to skills development taken by AMCOW in 2013 and 2018/2019 and the decision taken by the SADC minister of Water to support AUDA-NEPAD SANWATCE activities taken in 2013, and the regular formal noting and support for activities by the SADC ministers of Science and Innovation. Such support impact on the valorising of activities in the AUDA-NEPAD CoEs and contribute to the reputation of the CoEs as institutes of research and capacity development in the respective countries and regions. These ministerial decisions and formal noting of activities by ministers, contributed to a pathway to impact in the HCD activities of the ACEWATER project, as it provided a broader framework and added legitimacy to activities, which had a positive impact on stakeholder participation and valorisation of pilot courses.

- Research and capacity development activities, especially in ACEWATER II, significantly contributed towards knowledge production at an institutional level. It will take time for the research activities to percolate into policy decisions. However, in terms of the pilot training courses, the universities in the AUDA-NEPAD Networks of Water CoEs can consider such training as an asset to be used in future training. In some countries, such as Sudan and Ethiopia, initial pilot courses were presented, but due to the Covid-19 pandemic, the usual face-to-face training could not be undertaken in the other AUDA-NEPAD Water CoEs, which resulted in a re-alignment of activities towards online teaching and training. The impact this realignment of training will have been beyond this reporting period and should be monitored in order to identify the impact on various dimensions.

- The stakeholder engagement activities such as the consultative-, validation and regional stakeholder workshops purposefully involved key stakeholders from the
regional and national government, private industry, society and NGOs – this a clear example of “productive interactions” (Spaapen & van Drooge, 2011b), specifically designed into the ACEWATER project. At the very least, these workshops had the benefit of bringing a broad range of stakeholders in the national water sectors together, which resulted in a broader and more representative contribution to the national discourse, and again contributed towards knowledge production. By taking a leading role in organising the workshops, the reputation of AUDA-NEPAD Water CoEs as water sector knowledge and skills developers was further strengthened. In the case of SANWATCE where regional stakeholders from WaterNet and SADC Water Desk were present in regional meetings, the role of SANWATCE as a regional knowledge and skills developer was strengthened.

- Further evidence can be found where research and HCD activities in the ACEWATER II project actually contributed to policy interventions where, for example in Nigeria, the HCD activities in the ACEWATER II project contributed to policy interventions and stimulated the Nigerian National Technical Committee on Water Resources to request and approve mandatory courses for the local water sector. In addition, Nigerian government agencies were directed to sponsor their staff for further training especially at the NWRI. In Mozambique, the Ministry of Science and Technology actively took ownership of the HCD process initiated by IWEGA at Universidade Eduardo Mondlane to identify skills needs for the water sector, and which resulted in key proposals to skills development in the country. These are some examples of evidence of policy interventions and impacts.

There is some evidence, for example in Senegal, where the research activities and the long-standing relationship between the Check Anta Diop University and the OMVS River basin, has resulted in the research informing policy. Since academics are not always primarily involved in driving policy-making processes, some academics in the SANWATCE confirmed during the consultations in the regional meeting that they initially felt ‘out of their comfort zones’ while engaging with policy-makers, especially in the case of the HCD sector-wide assessment. However, it was found that the consultative workshops had a positive impact in that through the processes, individual and organisations growth took place, especially when the outputs were valorised, and academics experienced that their inputs were accepted.

The coordination of activities in the ACEWATER project has further strengthened the capacity of personnel at the secretariats of the WANWATCE, SANWATCE and CEANWATCE, and further indirectly lead to the promotion of the programme manager at
WANWATCE, the promotion of academics in Botswana and also at Makerere University in Uganda.

In all activities, the specific (and budgeted for) activity in the ACEWATER II project to organise in-country consultation and validation workshops and the series of regional stakeholder workshops created **pathways to impact** and contributed to building wider ownership of the process with and within key-stakeholder institutions such as ministries and relevant government institutions, and the Centres of Excellence. Concerning the element of additionality, relationships with key-stakeholders were developed over time, which contributes towards the success of the activity. However, the ACEWATER II project leveraged these relationships to new levels during the validation- and regional workshops, thus having a beneficial impact on the role the AUDA-NEPAD Water CoEs have to play in research and capacity development.

### 6.2 Recommendations

Based on the results of this study, the following section presents both general recommendations and specific recommendations.

**General recommendations**

- Even though it can be regarded as standard practice, the case related to Joint Learning confirmed that during the *development stages* of a project proposal, even before the project is commissioned, key stakeholders need to be engaged in designing activities, should there be a need for their eventual support. This does require time and effort, but as demonstrated by the AUDA-NEPAD Water CoEs, such engagement can be built over time, and existing relationships can be leveraged to provide input into project development.

- Moreover, in designing a project, **specific and significant budgets** need to be allocated to enable consultative workshops such as the consultative-, validation and regional workshops of the ACEWATER II project. This study confirms the value of well-designed workshops that span multiple days that should not be underestimated as they need to provide ample inputs for researchers, key stakeholders and decision-makers to make presentations, deliberate and provide input into eventual deliverables.

- Even if key stakeholders were not involved in the early design stages of the project proposal, activities such as workshops and validation workshops need to be undertaken during the *research process* itself, where key stakeholders could contribute, as it will contribute towards the uptake of the outputs.
• Where decision-maker support is required in a project, this study confirms that specific validation workshops add value to a project. Such ownership of decision-makers in the validation workshops significantly contribute to the support of deliverables.

• The timing of the sector-wide impact assessment is important. As proposed by the IOM Tools in the PayBackPLUS Framework, initial actions related to impact assessments should preferably be undertaken as early as the project design stages of a project. Although broad impacts were described in the proposal of the ACEWATER II project by the EC-JRC in their submission to the EC, detailed impact indicators and assessment criteria were not necessarily designed that target project outcomes and should be undertaken in future projects.

• In future projects, Impact Assessments should be designed in such a way that they support and feed into and benefit from results of a Monitoring & Evaluation (M&E) activity, from the outset of the project. The symbiosis should be established where the M&E activity identifies project outputs, and the Impact Assessment activities would focus on project outcome and impact pathways.

This impact assessment specific recommendations:

• To measure longer-term impacts of this support which will materialise over time, it is recommended that the participation in training courses are monitored and also the contribution of research to policy decision making and the benefits to society, economic benefits and ecological benefits, evaluated and analysed over the longer term. This must include continuous monitoring of outputs and pathways to impact and reported benefits.

• There is evidence in this study that the impacts that were realised in the phase I and II of the ACEWATER project, could not have been realised in isolation from the other project’s science and research-oriented activities, and that, for example, research and capacity development activities from ACEWATER I (2009 to 2015) and possibly other projects in WASSCAL, SASSCAL and the Pan African University contributed towards impacts. The evidence of such additionality of such activities should be investigated to capture a wider range of impacts of the ACEWATER project.

• The impact of the implementation of the pilot courses is being affected by the re-design of the HCD activities in the ACEWATER II project towards online teaching and learning, due to the impact of the Covid-19 pandemic in early 2020. An initiation of an impact assessment in the early stages of this re-alignment of activities, can assist greatly in potential pathways to impacts being identified and monitored early in the activity, and provide a more comprehensive view of the impact as the activity evolves over time.
• There is further a need to continue supporting the uptake of research into policy-decision making, and to support the societal-, economic and ecological benefits which can result from the foundation laid in the ACEWATER project. Evidence is there that the foundation laid through consultative workshops, and institutional agreements put in place to support the enabling environment, could provide a basis to accelerate the impact of the ACEWATER project.
7. Bibliography


Shaw B and Bell S. (2010). *How to evaluate the impact of environmental research on policy: Literature review.*


### 8. Annexure A: AUDA-NEPAD Networks of Water CoEs member institutions

<table>
<thead>
<tr>
<th>Institution name</th>
<th>Role</th>
<th>Country</th>
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<tbody>
<tr>
<td>Stellenbosch University</td>
<td>Secretariat of SANWATCE</td>
<td>South Africa</td>
</tr>
<tr>
<td>International Centre for Water Economics and Governance in Africa at Eduardo Mondlane University</td>
<td>Member of SANWATCE</td>
<td>Mozambique</td>
</tr>
<tr>
<td>University of KwaZulu-Natal</td>
<td>Member of SANWATCE</td>
<td>South Africa</td>
</tr>
<tr>
<td>University of Western Cape</td>
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<td>South Africa</td>
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<td>The Namibia University of Science and Technology</td>
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<td>Mauritius</td>
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<td>University of Cheikh Anta Diop</td>
<td>Secretariat of WANWATCE</td>
<td>Senegal</td>
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<tr>
<td>International Institute for Water and Environmental Engineering (2iE)</td>
<td>Member of WANWATCE</td>
<td>Burkina Faso</td>
</tr>
<tr>
<td>Institution name</td>
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<td>University of Benin</td>
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<td>National Water Resources Institute</td>
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<tr>
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<tr>
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9. Annexure B: Theoretical Framework

9.1 Introduction

This chapter provides a background and overview of the theoretical framework used for this study. In this chapter, the PaybackPLUS Framework will be presented. First, background and context on research impact assessment within the university and research environment are presented.

9.1.1 Accountability of universities and research institutions

Since the 1960s, greater awareness was seen of the importance of accountability emerged throughout the world. This growing need for accountability was complicated by less funding for research (OECD, 1997), creating greater pressure on universities to be more efficient and more accountable (Massey, 1996).

In the 1960s the Frascati Manual - also referred to as The Proposed Standard Practice for Surveys of Research and Experimental Development\(^2\), was produced by experts from the Organisation for Economic Co-operation and Development (OECD), and the National Experts on Science and Technology Indicators (NESTI) who met in Frascati, Italy. This manual provides basic definitions and conventions; institutional classification; functional distribution; measurement of R&D personnel; measurement of expenditures devoted to R&D; survey methodology and procedures and finally Government Budget Appropriations or Outlays for R&D by socio-economic objectives (GBAORD). Importantly, the Frascati manual structures different fields of research into main and sub-categories, which build on each other in a linear model. These main categories (or modes) are basic research, applied research and experimental development (OECD, 2002).

In the late 1980s and early 1990s, the emergence of the importance of accountability grew even greater throughout the world, with phrases such as “performance management revolution” being coined in the late 1990s by scholars such as Neely (Neely, 1999). This further saw the introduction of an approach referred to as New Public Management (NPM) whereby private sector/market-based techniques are applied to public service (Gruening, 2001; Hood,

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\(^2\) Updated versions of the document have been released over the years, with the latest being the 6\(^{th}\) edition in 2002. In 2007 an updated Field of Science and Technology (FOS) classification was published, in order to present the latest changes in emerging technologies such as ICT, biotechnology and nanotechnology. A further annex update was released in 2012 addressing the use of the OECD guidelines to measure R&D in developing countries. In April 2013, NESTI approved the commencement of the publication no a new revision, to be known as Frascati 7.0.
Universities and research institutions, such as in the case of partners in the ACEWATER project were also affected by NPM, with an increased application of bibliometric analyses (bibliometrics) whereby citation data and quantitative analysis are used to trace published literature, contributing to quantifying the contributions to knowledge production. This was followed in 1963 with the publication of the 1961 *Science Citation Index* (SCI) where the term “Impact Factor” was first used (Garfield, 1996), describing how the Impact Factor can be used as a citation-based measure, to indicate the significance and the performance of a scientific journal (Garfield, 1964, 1972; Persson, 2000). Today, the Impact Factor is widely used within the science community.

9.2 How do we measure the impact of research?

As will become evident, measuring the impact of research is multi-dimensional, with various aspects that need to be considered to measure the benefit of research and capacity development activities. First of all, measuring knowledge utilization is a process, and not a single event in time and consists of various generic steps, which includes Information transmission (the “trigger” step for knowledge utilization); Information pickup; Information processing and Information application, as presented in Figure 1. These steps can take a few minutes or occur over a long period of time and could involve a single user who could perform these steps cognitively, within an organization, within a network or by multiple users and organizations.

![Figure 1: Knowledge Utilization as a stepped process](image)

In addition, research impact assessments can be conducted either *ex-ante*, prior to the research to assess the potential significance and used to evaluate what the R&D project aims to do, or *ex-post*, once the research has been completed in order to measure the project’s final...
outcome and performance (Bulathsinhala, 2014). Moreover, most literature often focuses on *ex-post* evaluation of public R&D projects (Chiesa et al., 2009; Kimura, 2010; Lee et al., 1996; Sakakibara, 1997), or *ex-post* evaluation at a programme level (Arnold et al., 2005; Blumstein, 2010; Georghiou & Roessner, 2000; Hobday, 1988; Ormala & Vonortas, 2005; Vine, 2008).

In comparison, less *ex-ante* evaluations have been carried out possibly due to the difficulty in quantitatively measuring what a project will do as opposed to quantitatively measuring *ex-post*, what impact a project has had (Bulathsinhala, 2014). In addition, *ex-ante* evaluations are often used as an internal process, with a smaller audience than in the case of *ex-post* evaluations, thus adding to the difficulties in undertaking *ex-ante* evaluations as opposed to *ex-post* evaluations of R&D projects (Bulathsinhala, 2014).

### 9.2.1 Challenges in linking research to research impacts

There are challenges when the impact of research is identified and reported on. Some challenges related to attribution, additionality, time lag and the timing of assessments, which are discussed in more detail.

#### 9.2.1.1 Attribution, additionality and time lag

In measuring the impact of scientific research, the questions will always be asked if the research output is really the key driver for the eventual impact - *attribution* 1–3,33. This has led to some studies preferring to use language that focuses on the influence of research rather than impact (Boaz et al., 2009a). Moreover, questions will be asked on how the contribution of the research compares to that of other drivers – referred to as *additionality*, (H. Davies et al., 2005a), and would the same impacts be achieved without the research programme (Klautzer et al., 2011). There are some mitigating arguments which include the establishment of counterfactuals and by asking key informants about the outcomes they would have expected without the input of the research (Bell et al., 2011). In addition, the adoption of demand-side approaches to impact evaluation (as opposed to supply-side) and using major policy events to work retrospectively to establish influences and further to institutionalise impact evaluation processes and ensuring that staff take the responsibility to record outputs, dissemination efforts and known policy responses which directly relates to the research (Bell et al., 2011). Of importance though, when institutionalising impact evaluation process, is the risk of adding additional administrative burdens on staff (Wooding et al., 2007).

In addition, a challenge exists whereby the ability to quantify and establish attribution reduces over *time* 33. When research findings are published as outputs in the form of
reports and/or articles, initial-, intermediate- and final outcomes could take quite a while since the initial research output, with a decrease in the ability to track attribution as evident in Figure 2.

![Diagram of research outcomes](image)

**Figure 2: Losing attribution of research impact over time**

9.2.1.2 Timing of assessments

If the evaluation of the impact of research is undertaken too early after the conclusion of the research, the impact of the research might not have occurred yet, or if the evaluation is undertaken too late, some impacts might have occurred without a lasting effect. The challenge lies in capturing the duration of the research impact (Bell et al., 2011). As a possible solution, a two-stage evaluation process could be undertaken, with the measurement of impacts shortly after the project completion, and another later when the intended benefits should emerge. This suggestion is in line with Guinea et al. (Guinea et al., 2015) who propose, as part of Impact Orientated Monitoring (IOM) tools, that Coordinators’ surveys, End users’ opinion surveys and/or Assessment tools (scoring matrix) be undertaken in the middle of the project (for projects lasting four or more years), at the end of the project, or three years after the project.
9.2.2 Models and methods used for research impact assessment

Over a number of years, various models and frameworks have been developed to evaluate the impact of research and have been applied in various studies. Greenhalgh et al. (Greenhalgh et al., 2016) reviewed six of the most established approaches and their applications, which include the HERG Payback Framework, the Research Impact Framework, The Canadian Academy of Health Sciences (CAHS) Framework, Societal Impact Assessment and Related Approaches, the UK Research Excellence Framework and the Participatory Research Impact Model. Greenhalgh et al. (Greenhalgh et al., 2016) further identified other approaches which could hold future potential, and include electronic databases such as Researchfish® (Researchfish, 2016), Realist evaluation (Pawson, 2013; Rycroft-Malone et al., 2015), Contribution mapping (Kok & Schuit, 2012), The SPIRIT Action Framework (Redman et al., 2015), and the Participatory research impact model (Cacari-Stone et al., 2014; Jagosh et al., 2012). It was also found that most frequently, semi-structured interviews, case studies and documentary analysis are applied to the study of research impact (Boaz et al., 2009b). However, it was found that most studies used more than one research method. Other methods used and/or discussed included bibliometrics; peer panel reviews; surveys; workshops; literature reviews; field visits; user evaluations; telephone interviews; historical tracing; patents/ new technologies, network analysis, positive utilization narratives, impact logs and tracing post-research activity. It was also found that forward tracking of research is most used, from a piece of research to an outcome such as a policy change as opposed to backward tracking from an outcome to the research (Boaz et al., 2009b; S. Hanney et al., 2007) In addition, forward tracking tends to identify a greater level of impact, due, in part, to the reliance on self-reported data from lead investigators. However, it was further found that some research evaluators tracked research projects in both directions in order to create a high-level account of the relationship between research and policy (S. Hanney et al., 2007). In the studies (Boaz et al., 2009b; Greenhalgh et al., 2016) it was concluded that the HERG Payback Model is the most used.

9.3 The PaybackPLUS Framework

As will be presented, the HERG Payback Framework already identify four impact dimensions, which are the scientific or knowledge benefits derived from research, benefits to policy formulation, benefits to the economy and social benefits from research. It is however evident, that in recent years there has been an increased focus on what benefits could be derived from research in natural sciences, which could be expanded upon from the HERG Payback Framework. In addition, research related to Impact Oriented Monitoring Tools (IOM) (Guinea
et al., 2015) can be integrated into the HERG Payback Framework. For these reasons, an adapted PaybackPLUS Framework will be used for this study.

In the following sections, the elements and integration of IOM Tools of the PaybackPLUS Framework will be discussed.

9.3.1 Elements of the PaybackPLUS Framework

The PaybackPLUS Framework, presented in Figure 3, consists of two elements, which are 1) a logic model, representing the complete research process as research projects are conducted over time, and 2) a set of research impact dimensions to classify the individual paybacks from the research. In addition, the relationship between the research process and the different research impact dimensions are presented and indicate that scientific impacts relate to the scientific knowledge production, whereas the policy-, economic-, ecological- and social impact dimensions relate to the political-, professional-, economic- and ecological environments and the wider society.

9.3.1.1 Element 1: The logic model

The research process consists of seven stages, as presented in Figure 3 of the logic model. These stages include the Research Needs Assessment (stage 0) when the research project is initiated, followed by Inputs to research (stage 1); the Research process (stage 2); Primary outputs from research (stage 3); Secondary outputs from research (stage 4); Practitioners applications (stage 6) and finally Research outcomes (stage 6). Each of the seven stages of the logical model is discussed in more detail.
Figure 3: The PaybackPLUS Framework

Acknowledgement: Elema, N.M, Cloete, T.E
Initially, a research needs assessment (Stage 0) is undertaken with inputs from the reservoir of knowledge and inputs from the political-, professional-, economic- and ecological environments, and the wider society. Here, with inputs from the scientific body of knowledge and other stakeholders, the research question is framed and defined, often with various assumptions framing the research question, which could be potentially be mapped through impact pathway mapping and logic models (Shaw B and Bell S, 2010). The research needs assessment provides the motivation for the research, which could then be translated into a research proposal for potential funding.

Conducting research – moving from Stage 0 to Stage 3

Once the research needs have been identified and typically captured in a research proposal (Bordens & Abbott, 2002; Creswell, 2014), the research needs assessment stage is followed by the first of two interfaces within the research system. Interface (a), between Stages 0 and 1, provide the opportunity for researchers to draft the project specifications, where it is often submitted for funding. These could be in response to a call presented by local or international funding mechanisms to fund research projects, or as in response to established funding grants and where projects are evaluated and selected for commissioning. Only then, do research project pass on to stage 1, where inputs are gained from the scientific body of knowledge and the larger stakeholder group to initiate and conduct the research process in stage 2 for the eventual production of primary research outputs from the research in stage 3. It is important to note that inputs from the scientific knowledge and the broader stakeholder group in stage 1 continuously feed into the research processes in stage 2. The research process can take a number years depending on the type of research, but typically post-graduate qualifications, research publications, knowledge models and frameworks, patents and scientific knowledge products developed by the researchers result from the research over a number of years.

An enabling environment for research – Stage 1 to 3

When research is conducted, in Stage 1 and 2 and when primary outputs are produced from research in stage 3, creating an enabling environment is essential for the success of the research. Such research enablers include human resources and critical mass in terms of expertise in focus areas found in Centres of Excellence and Institutes supported by Research Chairs. Moreover, universities and research institutions rely on
funding from contract research, government grants, bursaries and philanthropic donations to enable research. In most cases, infrastructure is required, including research laboratories which often contain high-end and expensive research equipment. Finally, collaboration with other institutions enables training opportunities for postgraduate student support in the form of workshops and supervisor training, summer and winter schools, joint and double degree opportunities, and the sharing of high-end infrastructure, as mentioned earlier.

Research dissemination for secondary outputs and practitioner applications – moving from Stage 3 to Stage 5

The second of the two interfaces occur when between Stages 3 and 4 after the primary outputs from the research have been produced and disseminated from where secondary outputs are produced in stage 4. At this stage, decisions also need to be taken by the science communication practitioner on the modalities of science communication such as science promotion and science education, and the intended effect of the science communication process (van der Sanden & Meijman, 2012). Only after these knowledge products have been developed, are they “re-packaged” as secondary outputs such as policy briefs, policy- and legislative documents, information guidelines, and outputs aimed at the “non-academic” audience is produced (stage 4). Moreover, practitioner applications (stage 5) result from these secondary outputs and could further result directly from the primary outputs produced by the researchers in stage 3, and need not necessarily result from secondary outputs.

The logic model further acknowledges how the impact from research processes (Stage 2) and primary outputs from research (Stage 3) can have a direct influence on practitioners’ applications (Stage 5), with input into, and from, public engagement at these latter stages.

Public engagement

Following the dissemination of primary outputs from the research (Stage 3), public engagement is highlighted at stages 4, 5 and 6, when secondary outputs result from the research, practitioners apply the research and outcomes now result from the research in stage 6. In these stages, public engagement with stakeholders in the political-, professional-, economical- and ecological environments, in the wider society, assist delivering outcomes of the research.
Over the past number of years, a wealth of research has been undertaken on the field of research dissemination and research utilisation which provide insight into how research can be disseminated and utilised to influence policy-makers and practitioners.

*The interface between the body of knowledge and external stakeholders into the research process.*

Throughout the entire research process, from stage 0 when the research project is incepted to the outcomes in stage 6, inputs are gained from the scientific body of knowledge and broader stakeholders. In the early stages of the research process (when the research needs assessment and the initial stages of input into the research take place), the knowledge grabbing occurs from the reservoir of knowledge, feeding into the research process. The latter is repeated later in the research process when secondary outputs are generated (stage 4) and when practitioners' applications are being developed (Stage 5) – both these processes are influenced through systematic reviews which take place through the reservoir of knowledge. Moreover, the PaybackPLUS framework acknowledges inputs from the political, professional, economic and ecological environments and the wider society in stage 1 when inputs are gathered into the research conducted. This is often through stakeholder engagements such as workshops and meetings to gather data. Finally, as indicated earlier, public engagement when secondary outputs and practitioner application result from the research, support the outcomes in the research process.

**Feedback loops**

To create a feedback loop back to the research process, knowledge is fed from primary outputs of the research (Stage 3), the practitioners’ applications (Stage 5) and from the final outcomes (Stage 6) back into the policymakers secondary outputs (Stage 4). The feedback loop extends to when inputs into the research occur (stage 1) and at Stage 0 when the needs assessment into the research is undertaken.

### 9.3.1.2 Element 2: The impact dimensions

The second element of the PaybackPLUS Framework consists of a set of research impact *dimensions* (also refer to Figure 3). The research impact dimensions include

- Science impacts (such as knowledge and product development and further benefits to future research and research use),
Policy and practitioner impact such as benefits where research inform policy and product development.

Economic benefits derived from the research

Ecological benefits as they relate to the biosphere and

Benefits to society, where social impact can further be defined as socio-political-, socio-economic-, socio-ecological and socio-hydrological benefits.

Moreover, the various impacts manifest at various stages of the research process, with science impacts typically resulting in stage 3 as primary research outputs, the policy impacts as secondary outputs in stage 4, and economic, ecological and social impacts manifesting as outcomes in stage 6 of the logic model.

The individual dimensions are discussed in more detail:

9.3.1.2a Dimension 1: Science impact

*Dimension 1.1 Knowledge and product development.*

As researchers publish their work in journals, conference presentations, books, book chapters and research reports, findings are made public. Often, innovative scientific research also results in the development of products and techniques, which could include knowledge products such as theoretical frameworks, computer software, hydrological- and climate change models which are often used for further academic research.

Typical knowledge outputs include publications where any type of publication could be considered, but it is generally thought that peer-reviewed articles in international papers (Lewison & Devey, 1999) are most important, as they reflect quality, and papers that are accompanied by an editorial are seen as significant.

Master’s and PhD dissertations and also research reports which result from the research are often stored in local institutional libraries and often published in electronic format, are also regarded as knowledge and innovation products. Moreover, patent applications are an indication of innovative products resulting from scientific research. This dimension of research impact can directly be linked to the researcher as the author or patent applicant.

Over the years, international citation index databases such as the Thomson Reuters™ Web of Science™ and the Elsevier™ Scopus databases have been developed whereby the citation information of research papers are collected. These databases
provide insight into the scientific knowledge produced and are used to assess the impact of research papers in terms of scientific use and the research productivity of individual researchers. With the further development of altmetrics (Almind & Ingwersen, 1997), cited references in webometric databases such as Google Scholar are also useful but should be used with caution, as these developments are still in their relative infancy (Aguillo, 2012; Garfield, 2006; Wouters & Costas, 2012).

**Dimension 1.2: The benefits derived from current and future research use**

As recipients of funding for scientific research, researchers could be enabled to better target future research, leading to leveraging of future research and funding. The scientific research can contribute towards the development of research skills, personal and overall research capacity within fields of interest and expertise, and can result in a critical capacity to absorb and utilise existing research. Related impacts can also include personal (such as promotion) or institutional staff development.

Outputs would include employment of staff on research programmes, explicit funding for research training, and also in higher or research degrees resulting, either totally or in part, from research funding (Buxton et al., 2000; S. Hanney et al., 2003; Mushkin, 1979; Verhorn et al., 1982). The impact of such a dimension would typically be related to the individual researcher and potential collaborators, and also their organizations or institutions.

9.3.1.2b. Dimension 2: Policy impacts

**Dimension 2.1: Benefits from informing policy and product development.**

Research project findings can be used for a wide range of policy/decision making at any level and the ability to influence organizational or governmental policy through scientific research has been studied, resulting in various frameworks and models (Caplan, 1979; Jenkins-Smith & Sabatier, 1994; Knott & Wildavsky, 1980; R. F. Rich, 1979; Sabatier & Weible, 2007; Weiss, 1979). Such influence on policy could have been the initial objective of a research project or occurred inadvertently because of the research project. Policy interventions are often facilitated through policy briefs, guidelines, or by an individual being appointed in an influential position to affect such impact (E. Lindquist, 2001; E. A. Lindquist, 1990; R. F. Rich, 1990). By making their research more relevant to political and executive decision-makers, knowledge producers could contribute to such policy interventions through scientific research.
Typical outputs from this dimension include resulting national policies, local guidelines, and policies developed by those responsible for training/education/inspection. Training packages, curricula and audit and evaluation criteria are examples of this (National Institutes of Health, 2000). Other outputs could include policies about media campaigns (S. R. Hanney et al., 2004), and the adoption of policies and products (Buxton & Hanney, 1996) that would contribute to the impact of this dimension.

With projects with an ecological aspect, an example would include the global awareness and negotiations around climate change impact and resilience, which is a good example of how scientific output (in the form of climate change models) has informed discussions at the various Conference of the Parties (COP) meetings on Climate Change.

9.3.1.2c. Dimension 3: Economic impacts

*Dimension 3.1: Benefits derived within the broader economy*

Within a broader economy, scientific research could impact on the wider economic benefits from commercial exploitation of innovations arising from R&D related to the ecological environment. An example of such an innovation which has had a far-reaching impact on its industry, was the development of the biological nutrient removal process, or Bardenpho process whereby nitrogen and phosphates are removed from wastewater without the use of chemicals. First developed in the 1970s by Dr James Barnard of South Africa, this process has had unquantifiable positive impacts on water resources and costs in recycling water in many countries (University, 2012).

Benefits included in this dimension would be measured through indicators such as an increase in employment, working-days and profits, resulting in manufacture and sales (Rosenberg, 2002) of water-related products and services. Further benefits to the national economy could include an increase in exports and/or import substitution (Gadelha, 2000; Hale & Towse, 1995). Research in certain water-related aspects could also have had a positive impact on livestock, which could potentially have a positive impact on export.

Again, the challenge is to identify, attribute, and quantify benefits as a result of research undertaken. This could be achieved through an investigation of a few case studies resulting from the research.
9.3.1.2d. Dimension 4: Ecological impacts

**Dimension 4.1: Impact on the ecological environment**

The PaybackPLUS framework provides a dimension for the impact of research related to the ecological environment as various benefits can arise from the application of research project findings which have a positive impact on both fauna and flora within the ecological environment.

Benefits would include an increase in water quality and quantity, better management of floodwater or the return of a balanced natural sustainable ecological environment following ecological events such as floods and periodic droughts or, destructive human interventions. Benefits would also include an increase in the numbers of indigenous fauna and flora within an ecological area. Research into invasion ecology also offers insight into the impacts that alien plants have on the natural ecological environment and ecosystems. These impacts are often seen as negative, but sometimes positive where invasive species support the production of firewood, food, fodder, building material and nectar for bees (Richardson & Van Wilgen, 2004).

Moreover, in terms of Ecosystem Services (ESS), ecosystems, directly and indirectly, contribute goods and services to society in order to maintain human wellbeing (Daily et al., 1997; le Maitre et al., 2007). According to the report of the Millennium Ecosystem Assessment (ME Assessment, 2005), ecosystem services can be categorized in four main types which include the *provisioning* of food, freshwater, wood and fibre and fuel; the *regulating* of the climate, -flood, -disease and water purification; *cultural* contributions in the form of aesthetics, spiritual, educational and recreational and finally *supporting* primary production, nutrient cycling and soil formation. By making use of these main categories, the Common International Classification of Ecosystem Services (CICES) has developed a set of common classifications and indicators, especially where a link to economic accounting is made (Haines-Young & Potschin, 2013). The latest version 4.3 classifications and indicators were developed in 2013 and accessible at [http://cices.eu/](http://cices.eu/), which could be used as a guide to develop indicators for ecological impact.

9.3.1.2e. Dimension 5: Social impacts.

Since the 1990s there has been a clear trend to not only measure the impact of research on academia and scientific knowledge, but also an expectation that evidence needs to be demonstrated of the value of science to society (Martin, 2011). Various
social, cultural, environmental and economic returns or benefits can arise from research and the uptake of new products, which is not easy to separate 83, and, as further argued by Giddings et al. 84, these entities are interconnected with the economy dependant on society and the environment, while at the same time, society is dependant and within the environment. Moreover, within the ecological environment, this “interconnectedness” is highlighted in the definition of Integrated Water Resource Management (IWRM), which aim to promote ‘the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems’ (GWP-TAC, 2000).

The impact of research on society can be measured in various ways, and be “much harder to assess than scientific research” 83, with various advantages and disadvantages associated with different methods. Examples would include case-study methods that, even though they record the complexity of societal impact, can be very expensive, and do require a uniform approach with the same indicators in order to assess the impact of different institutions.

Within the PaybackPLUS Framework, the various societal benefits are associated with the political-, economic- and ecological benefits as mentioned earlier. As first sub-dimension Socio-political benefits are derived, where sociologists work to better comprehend the operations and constraints of organizations with political influence, thus bringing them into the water policy dialogues, and a better environment can be created that can better collaborate with other water-related disciplines to address water problems in an area. (Brown et al., 2009; Freeman, 2000). Moreover, socio-economic benefits can be achieved from improved health as a result of better water purification techniques (Andreozzi, 1999; Malik, 2001; Theron et al., 2008) or a decrease in water pollution where communities rely on such water sources (Brix, 1994; C. M. Davies & Bavor, 2000; Dosskey, 2001). Moreover, cost savings could occur, with benefits to society, through sustainable development (Omer, 2008; Paumgartten, 2003; Wong et al., 2003). Socio-ecological benefits could include an increase in the establishment of a food-secure environment (Altieri, 2004; McClanahan et al., 2009). Lastly, the PaybackPLUS framework provides for benefits derived through a better understanding of the socio-hydrology, where the focus of socio-hydrology is on “observing, understanding and predicting future trajectories of co-evolution of coupled human-water systems” and can be seen as the science which underpins the practice of IWRM (Sivapalan et al., 2012). Benefits from a socio-hydrology perspective would be for
example in the case of human-flood interactions (Di Baldassarre et al., 2013; Lane, 2014) and the development of flood-warning systems.

Challenges within this impact-dimension are the attribution of research impact in such a broader impact-dimension, and to relating such impact directly to the scientific research.

9.3.2 Strengthening the PaybackPLUS Framework by making use of Impact Orientated Monitoring (IOM) tools

As indicated earlier in this study, attributing research impact to a specific research project is a challenge. Moreover, such attribution decline over time (Boaz et al., 2009a). A study (Guinea et al., 2015), does propose a set of Impact Orientated Monitoring (IOM) tools at various stages of a research project. Having presented the two elements of the PaybackPLUS Framework above, being the local model (research process), and the various research impact dimensions, such IOM tools can be integrated into the PaybackPLUS Framework to strengthen the identification, monitoring and attribution of research impact.

<table>
<thead>
<tr>
<th>IOM elements</th>
<th>Purpose</th>
<th>Timing</th>
</tr>
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<tbody>
<tr>
<td>Project results matrix</td>
<td>To structure the expected results and impacts.</td>
<td>During negotiations for a grant agreement.</td>
</tr>
<tr>
<td></td>
<td>Assess specified short-term impacts.</td>
<td></td>
</tr>
</tbody>
</table>
| Coordinator survey.           | The main data collection tool (web-based questionnaire) for the capturing of results and evidence of research impact. | • For projects of more than four years, in the middle of the project.  
|                               |                                                                         | • At the end of the project.                |
| End-users’ opinion survey.    | A web-based questionnaire to gather data on end-users’                  | At the end of the project.                 |
|                               |                                                                         |                                             |
opinions on non-academic impacts of the research project.

Source: (Guinea et al., 2015)

The IOM tools within the PaybackPLUS Framework consist of three elements, including 1) a Project results matrix, 2) a coordinator survey, and 3) an end-users’ opinion survey, as presented in Table 1.

Figure 4: Integrating IOM tools into the PaybackPLUS Framework

Referring to Figure 4, the integration of IOM Tools at various stages of the PaybackPLUS Framework are indicated. Starting very early in a research project and at the initial stages of project conceptualisation, the Project results matrix would feed from, and influence, the project specifications at the first Interface (a) between stage 0 and stage 1. This influence would take place during the grant negotiation process and assist in organizing project information and linking objectives with activities, results and the impacts. It is important that researchers start identifying potential research impact dimensions over the broad spectrum of dimensions as provided by the PaybackPLUS Framework. Project results matrix can be referred to by the coordinator of the research project when periodical reporting on the project occurs. Moreover, such forward tracking would further support the tracking of
research impacts as forward tracking tends to identify a greater level of impact (S. Hanney et al., 2007). Forward tracking of research impacts is also identified by Boaz et al. (Boaz et al., 2009b) as the most common method used for tracking research impact, as opposed to backward tracking.

In addition, a coordinator survey could be undertaken in stage 2, during the research project, feeding into the research process, and at the conclusion of the project, when the final outcomes from the research are potentially reached (Stage 6). Such coordinator surveys would assist in collecting data about project results and evidence from the research project. Results of this survey should feed into the knowledge reservoir for future reference. Where a project last more than four years, a coordinator survey should take place in the middle (following Stage 3, when the primary outputs from the research are achieved) is also recommended. The questionnaire will collect quantitative and qualitative data on the advancement of knowledge; capacity building and research targeting; informing of decision-making, practice and policy; social benefits, ecological environment benefits; broader economic benefits, and data on dissemination and knowledge transfer. Guinea et al. (Guinea et al., 2015) recommend that such a coordinators’ survey be repeated three years following the conclusion of the research project, to obtain evidence of outputs and impacts, and how these relate to the final outcomes as identified in Stage 6 of the Payback Framework. Again, results from this survey should feed into the knowledge reservoir for future reference, and into the political-, professional-, economic- and ecological environments and wider society.

The third IOM tool, as defined by Guinea et al. (Guinea et al., 2015), is an end-users’ opinion survey which is now integrated following stage 6 of the PaybackPLUS Framework, when the final outcomes are potentially achieved and public engagements have concluded. Such a survey would assist in identifying non-academic impacts and identifying high impact projects. It is, however, important that the researchers involved in the project clearly identify the most relevant end-users to take part in the survey questionnaire, and that project officers actively participate in the monitoring of projects, as they will have to contact and motivate end-users to participate in the survey. As in the case of the final coordinators’ survey, results from this end-users’ opinion survey should feed into the knowledge reservoir.

9.4 Data collection techniques for the PaybackPLUS Framework dimensions

To operationalise the PaybackPLUS Framework, data collection and analysis techniques are identified for each of the five research impact dimensions. These techniques include bibliometric methods, documentary reviews, personal interviews, analysis of student and funding statistics, user surveys and selected case study analysis. For example,
• bibliometric methods such as citation analysis, interviews with researchers and the analysis of patents, licenses, will be undertaken when primary outputs such as publications are produced to identify the contributions a project has made to the knowledge production and the benefits to research and research use.

• To identify the contributions to policy, reviews of secondary outputs such as national; regional and local regulations, existing policies, acts, laws or regulations, document review and interviews could be undertaken to assess to what degree informed decision-making has occurred.

• Broader economic benefits from research can be identified through, surveys, personal interviews and selected case studies, often in later outcome stages of a project - for this dimension, statistics would also be important.

• The determine the impact on the ecological environment, various quantitative and qualitative techniques could be used. For example, data from measurements related to the health of an ecosystem such as improved water quality and water quantity; the number of species of fauna and flora and further counts of fauna and flora in an area; the use of Common International Classification of Ecosystem Services (CICES) as available from http://cices.eu to identify indicators for Eco-System Services (ESS); personal interviews and selected ecological-related case studies.

• Lastly, various data collection techniques could be used to identify Socio-political impacts, Socio-economic impacts, Socio-ecological impacts and Socio-hydrological impacts. Measurements include identification of actors involved in water resource management; the identification of forums and arenas for discourse on water resource management; the measure or review of the level of service; review and analysis of user complaints; compliance with quality standards; the level of awareness of water health; review or study of existing training and knowledge building initiatives; analysis of decrease (or why not increase also?) in the loss/improvement of crops, and human and animal life in the case of floods; selected case studies and relevant statistics data can be collected and analysed. it should be acknowledged that such societal contributions are often only realised as outcomes after a few years, and often after the completion of a research project.