1. Economic Aspects of IWRM – an Introduction to the MOSA Pilot Project

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The Institute of Environmental Engineering and Management at the Witten/Herdecke University is an autonomous, non-profit research institute. IEEM combines the academic fields of environmental engineering and economics into an applied scientific approach. Technology and economics are the foundations of the work of IEEM and a precondition to develop modern management concepts and organisational models, which are needed to design and realise both technical and institutional solutions, focused on efficiency for environmental protection and supply services. IEEM focuses on topics of water and sanitation, closely linked to applied environmental economics. IEEM has many years of experience in developing, coordinating and implementing international water projects in Europe, Asia, South America and Africa.

1.1 Integrated Water Resources Management

1.1.1 Conceptual background

Water scarcity and water-related risks represent an increasing threat to many countries in the world. Providing stable freshwater supplies is a major challenge for water stressed countries. Various measures, both supply enhancement techniques and demand management strategies[1], are being introduced to tap new resources and to improve the efficiency and sustainability of water use (e.g. Ohlsson & Turton 1999). A multitude of these measures is subsumed under the keyword ‘Integrated Water Resources Management’ (IWRM).

Especially after the formulation of the Dublin principles in 1992, which had a strong impact on Chapter 18 of the Agenda 21 formulated at the UN Conference on Environment and Development held in Rio de Janeiro (UNCED 1992), many IWRM definitions have emerged and a lot of different tools, methods and approaches are labelled with the keyword or buzzword (Van der Zaag 2005) ‘IWRM’. One of the most popular definitions of IWRM has been elaborated by the Global Water Partnership:

> IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable matter without compromising the sustainability of vital ecosystems. (GWP 2000, p. 22)

1 For a short introduction to the distinction between supply enhancement and demand management see Griffin (2006), pp. 3–5.

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Due to the different regional situations and preconditions of water management areas and river basins respectively, the content of IWRM remains ambiguous. Regional and national institutions must develop their own IWRM practices with regard to the relevant context (GWP 2000, pp. 6–7). The iterative character of the whole IWRM process is illustrated by the spiral model (UNESCO 2009, pp. 4–6) which highlights the fact that IWRM is an adaptive step-by-step management process. Continuous monitoring and evaluation permits an adaptation to new demands and changing circumstances at each stage of the process – or 'turn of the spiral' (Figure 1-1).

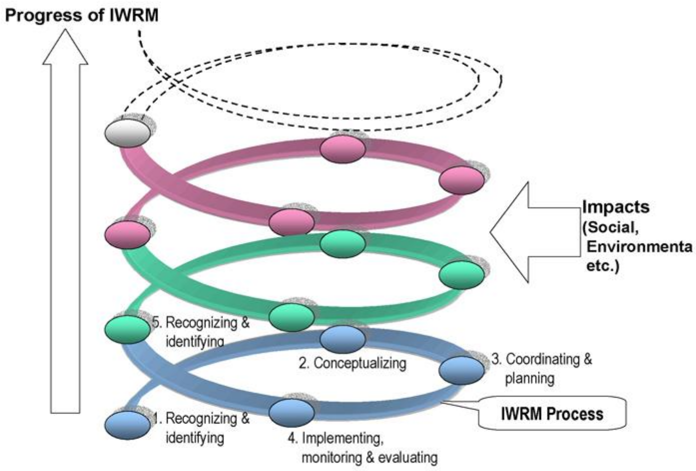

Figure 1-1: IWRM spiral and process
(UNESCO 2009, p. 5)

The application of IWRM principles implies a paradigm shift from building / construction – "the hydraulic mission" (Allan 2003, p. 10) – to holistic political processes and participatory management approaches including economic tools for dealing with scarcity. Because of various local conditions and different areas of application, "water problems of the world are neither homogenous, nor constant or consistent over time. They often vary very significantly from one region to another, [...], from one season to another, and also from one year to another" (Biswas 2008, p. 6), the concept of IWRM is not clearly defined and is subject to modifications. It is a multi-dimensional approach including physical (the resource itself), non-physical (water users, institutional framework, policies), spatial (distribution of water resources and uses as well as spatial scales of water management) and temporal (sustainability) dimensions of water resource management (e.g. Savenije & van der Zaag 2000).

1.1.2 *IWRM – a 'fuzzy concept'?*

To a certain degree IWRM is like Forrest Gump's famous box of chocolates – "you never know what you're gonna get" (Forrest Gump 1994). But is it a fuzzy concept, "a process which possesses two or more alternative meanings and thus cannot be reliably identified or applied by different readers or scholars" (Markusen 1999, p. 870), or does the IWRM approach provide benefits for decision makers, water professionals and stakeholders dealing with water scarcity and water related risks?

In fact, there is a risk that IWRM as an evolutionary process will be overloaded with numerous, sometimes antagonistic demands and expectations. From e.g. stakeholder participation to the integration of institutions and cross-sectoral planning, from supply enhancement and the development of alternative and non-conventional water resources (Thomas & Durham 2003, p. 21; Boutkan & Stikker 2004, p. 153) to demand management, efficiency improvement and conservation measures (e.g. Brooks 2006, Claassen 2013, p. 327), consideration of the ecological reserve (e.g. the South African National Water Act (RSA 1998)) and contribution to Millennium and Sustainable Development Goals (MDGs & SDGs), capacity development (e.g. Alaerts & Kaspersma 2009), gender issues (GWP 2006), economic development and growth – there is hardly any topic which has not been named in the context of IWRM.

This lack of conceptual clarity and several contradictions between the three basic elements of IWRM (e.g. Molle 2008, p. 133), ecosystem sustainability, social equity and economic efficiency (Figure 1-2) as well as conflicts between different users and uses result in a fundamental critique of the IWRM concept, especially with regard to the transfer of comprehensive theoretical concepts into practically applicable methods (Jeffrey & Gearey 2006, p. 5) and successful implementation (Biswas 2008).

Figure 1-2: General framework for IWRM (GWP 2000, p. 31)

On the other hand, several positive aspects have to be taken into account: IWRM has served to put social and environmental issues on the water management agenda, inspired a new generation of water professionals and provides assistance with achieving global development goals (van der Zaag 2005, p. 870) such as the MDGs and SDGs. It encourages out-of-the-box thinking and the development of new, flexible management concepts under uncertain conditions. Participatory elements play an important role in IWRM, Molle (2008, p. 150) calls it a “Nirvana concept, [...] a consensual reconciliation of antagonistic worldviews and interests”, providing an overarching framework for the development of water management models and concepts.

Albeit providing little practical guidance, the IWRM concept “is seen as an important way to manage water by most academics and policy makers” (Gupta et al. 2013, p. 576). But since successful application requires a strong enabling environment, clear institutional structures, transparent decision making processes, solidly financed infrastructure investments and effective instruments to support water management (e.g. Lenton & Muller 2009, p. 9), a clearly defined and focused IWRM concept with practical guidelines is needed to close the implementation gap. This also includes a framework of regularly monitored and reviewed strategic guidelines and targets to avoid getting lost in secondary issues, details and case-by-case short-term decisions.

1.2 The MOSA Project – Integrated Water Resources Management in the 'Middle Olifants' river basin, South Africa, Phase II

1.2.1 BMBF funding priority

The German Federal Ministry of Education and Research (BMBF) supports the development of integrated planning tools for the sustainable use of water resources. The protection and sustainable use of scarce water resources plays a decisive role for the future of humankind. The Federal Government supports the attainment of development targets such as the MDGs and SDGs by funding several pilot activities in the field of drinking water supply and wastewater disposal in numerous partner countries as part of the 'Research for Sustainability' (FONA) framework programme (BMBF funding priority IWRM 2015).

With the IWRM funding priority, the BMBF aims to strengthen the concept of IWRM in developing and emerging countries. Improving the living conditions of people living in water scarce areas as well as supporting and strengthening international cooperation in the field of science and technology are two major goals of the funding priority. It has the aim of developing adapted and transferable IWRM concepts in selected model regions worldwide. BMBF supports seventeen joint research projects with partners from universities, research facilities and industrial partners, which started between 2006 and 2010 (Ibisch et al. 2013, p. 9). The Middle Olifants river basin in South Africa is one of these model regions.

1.2.2 MOSA project region

The deterioration of water quality is among the most serious concerns in Africa with considerable ecologic, economic and social repercussions. Polluted rivers tend to aggravate water scarcity and in many regions water demands are already at their peak for consumption and production purposes. The MOSA project region is a part of the Olifants River catchment (Figure 1-3), which "is currently one of South Africa's most stressed catchments as far as water quantity (due to high demand) and water quality is concerned" (DWA 2011a, p. 2). Furthermore, over-exploitation is exacerbated by a water resources management uncertainty due to the regionally variable climate and global climate change. In some parts of the country, 2015 is the warmest year on record (CSIR 2015) and "due to prolonged lower-than-normal rainfall since the beginning of the year, drought conditions are being experienced across the country" (DWS 2015).

The Olifants River originates east of Johannesburg and flows northwards through mining and industrial centres. The MOSA project region, the Middle Olifants catchment downstream of the Loskop Dam to the confluence of the Steelport River, is dominated by rural areas, extensive irrigation and subsistence farming. The area of the Middle Olifants catchment is 22,550 km². The length of the main Olifants River in this area is about 300.94 km. Afterwards the river curves in an easterly direction through the Kruger National Park (KNP), a world renowned nature conservation area, into Mozambique (DWA 2011b). A multitude of different economic activities from mining, manufacturing and power generation to agriculture, domestic use and ecotourism, and various water uses and competing demands increased steadily over the years resulting in a progressive decline of water quality (Ashton & Dabrowski 2010, p. 103).

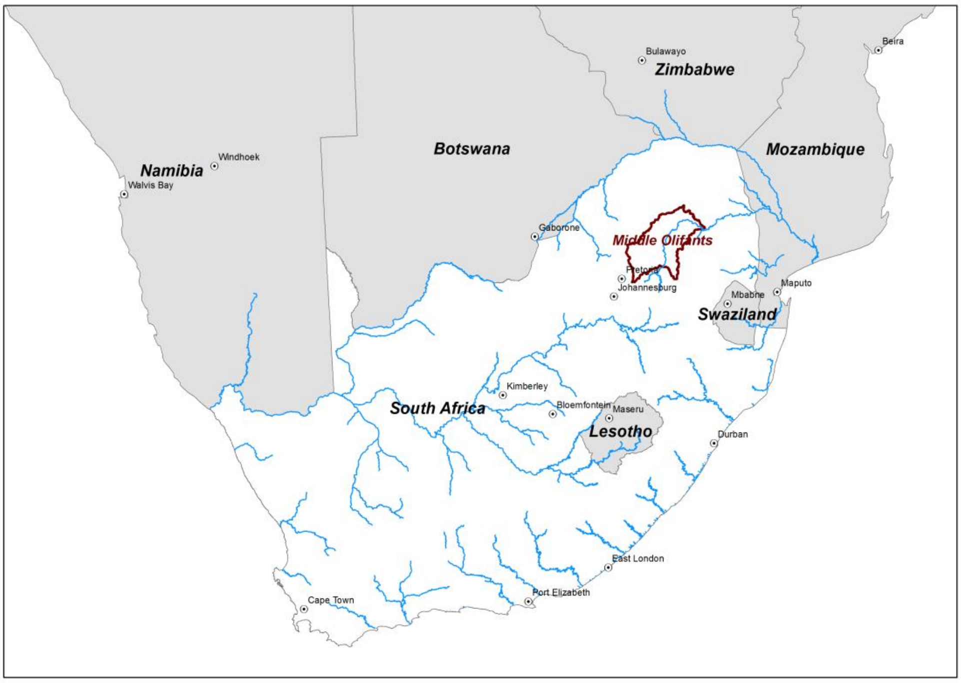

Figure 1-3: Location of the MOSA project region in South Africa (Jolk et al. 2015, p. 2)

The climate in the Middle Olifants region is semiarid. The evaporation in the Olifants catchment area is significantly higher than the precipitation at almost any point. The mean evaporation losses are between 1300 mm and 2400 mm. A small amount of the precipitation runs off, since the largest proportion of precipitation evaporates. Water users in the Middle Olifants suffer extended dry seasons compared to other catchment areas, because at the end of the dry season the usually empty reservoirs in the upper reaches (Upper Olifants sub-basin) are filled first before there is significant effluence into the Middle Olifants. The highest terrain elevation in the Middle Olifants is 2121 m, the shallowest point is at 577 m above sea level. The large differences in elevation and geographical continental location lead to cold winters (up to minus 4 °C) and hot summers (up to 45 °C) (De Lange et al. 2005).

According to Claassen, Funke and Nienaber (2013), the current state of the SA water sector institutional landscape is primarily characterised by noble intentions but also by a lack of effective action – some parallels to the criticism of the general IWRM concept are obvious. They place strong emphasis on implementation and enforcement of a sustainable policy taking into account Reserve[2] requirements to progress towards a sustainable water sector status (Claassen et al. 2013, p. 148).

South Africa is well suited as an IWRM research project region from other points of view as well: On the one hand it features of highly developed technologies and a sufficiently stable administration. On the other hand, South Africa displays all the characteristics of a 'real' developing country, especially in remote rural areas like in the Middle Olifants region. The most important point, however, is that South Africa is seen as being the 'gateway' to the Southern African Development Community (SADC) and the whole African continent as far as the adaptation and dissemination of innovative concepts and solutions are concerned.

1.2.3 MOSA concept

1.2.3.1 Phase I (2006–2010)

The socio-economic and environmental situation of the Middle Olifants region requires a holistic approach to achieve a more efficient and sustainable management of available water resources in accordance with the NWA. The NWA states that "sustainability and equity are identified as central guiding principles in the protection, use, development, conservation, management and control of water resources" (Republic of South Africa 1998). During Phase I of the project (2006–2010) a modular IWRM model has been developed for the Middle Olifants to be able to combine hydrological data with institutional regulations and economic criteria (Rudolph et al. 2011).

The Modular IWRM Concept

A core innovation of the MOSA IWRM methodology is the approach to structure the IWRM model in the same way as IWRM outcomes are utilised in different fields of expertise and water management. So far, IWRM has often been focused (and sometimes limited) to e.g. hydrological aspects and economic aspects have not been presented in a way that could be of use for concrete decision making outside the academic world, such as for water investment finance.

The model consists of three modules (Figure 1-4) which calculate the available yield of water (**Water Resources Module**, WRM) and an optimised water utilisation and allocation (**Water Utilisation Module**, WUM) to derive technical, economic and institutional measures to improve the water situation and to secure a sustainable management of the water resources (**Water Intervention Module**, WIM). The modules are in a reciprocal relationship: each modification of one of the modules impacts on the other modules.

2 The Reserve is a fundamental component of the NWA and the only right to water in South African law, defined as "the quantity and quality of water required to satisfy human needs [...] and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource" (RSA 1998, 1.1.xviii).

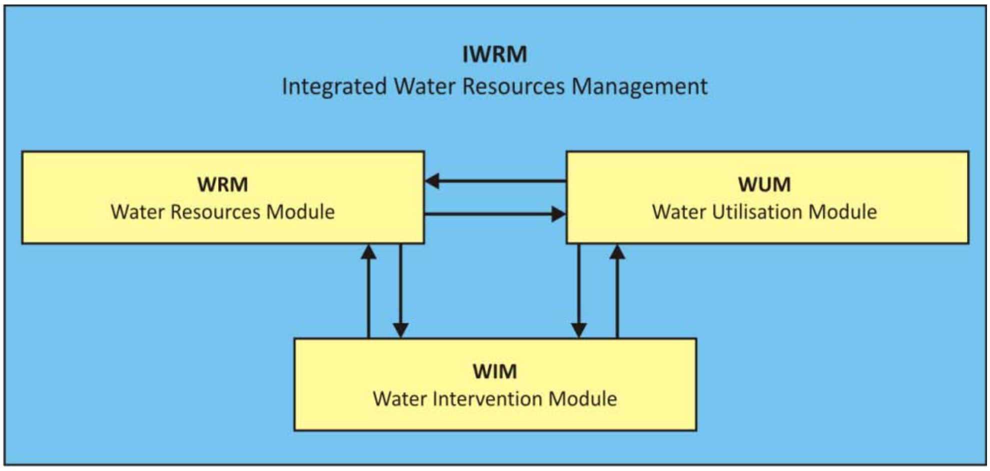

Figure 1-4: Modular IWRM concept
(Compiled by the authors)

With regard to sustainability the actual non-priority water consumption of 400m m³/a, i.e. any water use beyond the Reserve, has to be reduced to 232m m³/a in order to secure the future availability of the scarce resource (Bombeck 2013, p. 136). In consideration of utility maximisation as economic aspect, irrigation would have to face the largest total reduction, "water-use rights will in future be transferred from agriculture to industry" (Nieuwoudt & Backeberg 2011, p. 703), but also mining and domestic use have to be reduced to comply with the ecological Reserve as legally required (Bombeck & Rudolph 2013, p. 40).

Iterative computation of the modules WRM and WAM has shown that integrated management results in better protection and efficient allocation of the scarce water resources in the project region. The main cause of the water-related problems in the project region is not water scarcity, but insufficient water resources management (Rudolph et al. 2011, pp. 140–141).

During the progress of Phase I, especially while working on module WIM, the research group came to the following conclusion: For a successful implementation of IWRM, it is inevitable to have a structure of technical and legal conditions to assure the sustainable operations and maintenance of water facilities, but also a structure that creates economic incentives and sources of financing at the local level. These interventions to promote the involved parties' interest to continuously improve and apply trained knowledge and skills are summarised under the term "incentive engineering".

1.2.3.2 Phase II (2012–2016)

Building on the findings of Phase I, the second phase of the MOSA project focuses on intervention measures to increase the added value of all water-related activities in a sustainable manner. The modular IWRM concept has been further developed and improved. This includes an update and extension of the Water Resources Module as well as enhanced studies for the Water Utilisation Module in order to provide a sound basis for the practical interventions and pilot measures. "Finance and good water governance are inextricably linked" (Grau & Hall 2012, p. 5): all recommendations of the Water Interventions Module are developed with a strong focus on economy and financing, as sound financial arrangements are important to ensure a lasting success, especially in consideration of specific needs of the poor (e.g. Marin 2009, p. 107; Zetland 2011, pp. 210–211).

Phase II of the applied research project includes four main components (Figure 1-5) to ensure the implementation, transfer and dissemination of the project results. Accompanying awareness raising and capacity building measures complement the activities. The project group consists of three academic and five industrial partners working in close cooperation with South African partners and stakeholders to identify solutions for the water-related problems of the project region and to improve overall water management.

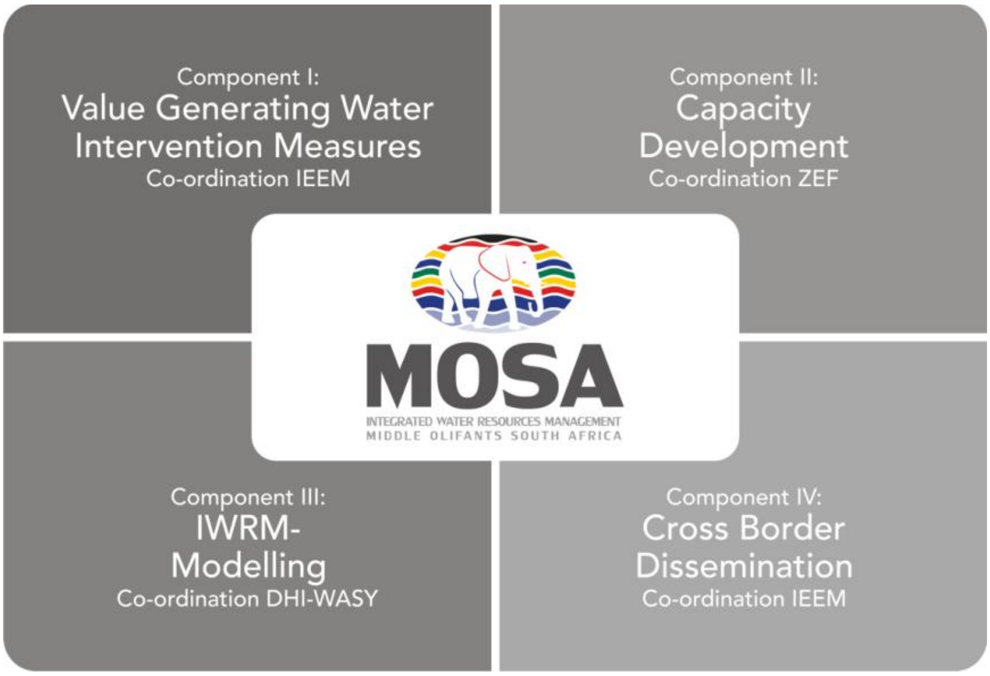

Figure 1-5: MOSA components
(Compiled by the authors)

The improved modular MOSA IWRM concept can be adapted to the preconditions of any target region. This allows to transfer the concept and to customise the three modules according to the requirements of future users and stakeholders. The concept developed under MOSA has been adapted for the first time in 2015 by the Lake Victoria Basin Commission (LVBC) for an IWRM programme funded by the European Investment Bank (EIB) and the German Kreditanstalt für Wiederaufbau (KfW). It will help to support the LVBC's and East African Community's joint water resources management and development programme (Mwinjaka 2015, pp. 32–34).

1.2.4 Outlook

The MOSA project addresses a wide range of water challenges and water-related research questions. The present publication of the academic and industrial project partners summarises their practical intervention measures, case studies and novel approaches to water management. This includes policy approaches and technical measures as well as economic aspects, given the "importance of developing appropriate economic methods and instruments to address many of the economic trade-offs that are apparent in water management" (Anderson et al. 2008, p. 667). Research and implementation were carried out in close cooperation with several South African partners. In addition to the detailed description of MOSA subtasks, this volume includes statements of South African project partners and stakeholders which highlight the fruitful collaboration.

A collaborative study of South African water researchers and experts published in 2014 provides an overview of priority water research questions for South Africa. MOSA contributes to a number of these "questions [...] categorised under the themes of change, data, ecosystems, governance, innovation and resources" (Siebrits et al. 2014, p. 199). These are, among others, the improvement of municipal water and wastewater services delivery, real-time water data collection, use of monitoring and information systems, reduction of river pollution, effective water policies and water resource allocation to maximise sustainable economic, social and environmental benefits (ibid., pp. 206–207). The following overview includes a short description of the MOSA subtasks and the contribution of the German MOSA partners to the project. The next chapters of the volume provide more detail and case studies of the MOSA project and its subtasks.

Planning and Decision Support Tools based on risk assessment for water quality have been developed by the institute of Environmental Engineering + Ecology (EE+E) at Bochum Ruhr-University and Disy Informationssysteme. The web-based system has been implemented at the Department of Water and Sanitation (DWS) since 2015 (Chapter 2.1). A detailed water resource model for the project region has been developed by DHI-Wasy, taking the MOSA phase I WRM model to a new level. Additionally, an educational game for awareness raising and capacity building has been developed, which was used e.g. for the 2014 South African Water Game Challenge in cooperation with the Water Research Commission (WRC), South African National Parks (SANParks) and other partners (Chapter 2.2). In order to monitor water quality and to provide fast and reliable test results, a mobile on-line laboratory has been designed by LAR Process Analysers. The mobile laboratory has been manufactured in South Africa and was tested and demonstrated under several monitoring campaigns in cooperation with DWS, the Council for Scientific and Industrial Research (CSIR), the Water Technologies Demonstration Programme (Wader) and local partners and stakeholders (Chapter 2.3). The Center for Development Research (ZEF) at the University of Bonn conducted economic studies on the implications of water policies on transaction costs, water use efficiency and water quality with a special focus on the agricultural sector. Research was carried out in good partnership with the University of Pretoria and other academic partners (Chapter 2.4). IEEM has analysed international supply and value chains of water management, economic measures such as infrastructure investment programmes and financial instruments to develop sustainable economic interventions for the water sector. These intervention measures have been elaborated in close collaboration with development banks such as the Development Bank of Southern Africa (DBSA), KfW and other partners and stakeholders from administration, academia and industry (Chapter 2.5). Operational concepts, business models and investment schemes for malfunctioning wastewater treatment plants (WWTP) as well as training tools have been developed by REMONDIS Aqua International. Case studies have been carried out in cooperation with local municipalities in Mpumalanga and Limpopo (Chapter 2.6). HUBER has demonstrated and tested a pilot plant basing on a combination of biological wastewater treatment and membrane filtration which can be used for WWTP refurbishment. Test series have been carried out in Germany and under South African conditions at Loskop Dam in the Olifants catchment. Furthermore, E-learning tools have been developed for training purposes (Chapter 2.7).

The findings have been presented and discussed on annual project status workshops with South African partners and stakeholders. Awareness campaigns and capacity building activities such as the South African National Water Game Challenge 2014 (Figure 1-6a), co-funded by the WRC (e.g. Letshala & Pott 2014), and the Water Research and Management Days 2015 (Figure 1-6b) in cooperation with SANParks, WRC, the South African Environmental Observation Network (SAEON) and the Association for Water and Rural Development (AWARD) were part of the accompanying dissemination and outreach activities.

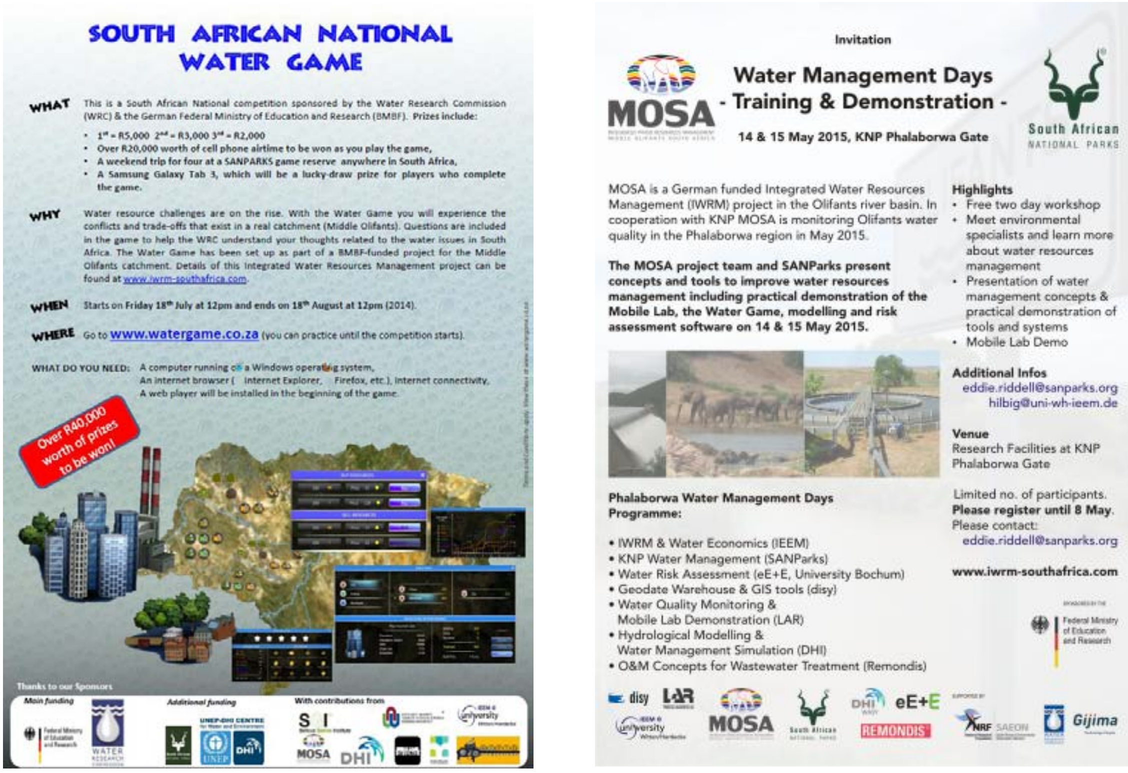

Figure 1-6: MOSA awareness raising (a) and capacity building activities (b)

Chapter 3 provides a final summary of the project findings including an outlook and recommendations for further research, policy making and implementation. The MOSA findings and recommendations are a contribution to basic IWRM research as well as specific South African water challenges and an attempt to transfer the IWRM concept into practically applicable methods. The authors of the present publication welcome any feedback and remarks on the entire project or any of the subtasks.

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