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A regional and multi-faceted approach to postgraduate water education – the WaterNet experience in Southern Africa

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Abstract. This paper reports the experience of a regional network of academic departments involved in water education that started as a project and evolved, over a period of 12 yr, into an independent network organisation. The paper pursues three objectives. First, it argues that it makes good sense to organise postgraduate education and research on water resources on a regional scale and presents the WaterNet experience as an example that a regional approach can work. Second, it presents preliminary findings and conclusions that the regional approach presented by WaterNet did make a contribution to the capacity needs of the region both in terms of management and research capacity. Third, it draws two generalised lessons from the WaterNet experience. Lesson one pertains to the importance of legitimate ownership and an accountability structure for network effectiveness. Lesson two is related to the financial and intellectual resources required to jointly developing educational programmes through shared experience.

1 Introduction

Established in 2000 in response to the call by water ministers of the Southern African Development Community (SADC) to boost the training of water professionals (Savenije and Van der Zaag, 2000), WaterNet links 65 university departments and institutions in 15 countries in Southern and Eastern Africa that share an interest and expertise in water-related issues. Individually they do not command the broad field of water resources management. By pooling their expertise they are, however, able to cover the full range, from hydrology to aquatic ecology, and from water supply and sanitation technologies to economics and law (Wright et al., 2001). In the process the region moves away from concentrated expertise to distributed expertise; from competition between centres of excellence to cooperation, and from conformity to a diversity of ideas.

As a network of institutions, WaterNet has created a modality that offers a regional Masters programme in Integrated Water Resources Management (IWRM). In addition to the regional Masters programme, WaterNet also offers short professional courses, carries out multidisciplinary water research programmes, and organises annual regional water symposia (Jonker and Van der Zaag, 2010).

WaterNet is premised on the idea that it makes good sense to organise postgraduate education and research on water resources on a regional scale. This is because water has a transboundary dimension that: (i) poses delicate sharing questions, (ii) needs an approach that promotes a common understanding of what the real water-related issues are, (iii) requires future water specialists speaking a common (water) language, (iv) enhances mutual respect and can thus be considered and investment in future peace (Van der Zaag, 2009a).

The paper reports on a first attempt at evaluating the success of WaterNet's contribution to water education and research in the SADC region. This it does by:

1. giving a description of WaterNet;
2. presenting preliminary findings of the success of WaterNet in contributing to the capacity needs of the region;
3. presenting some findings on the research output facilitated by WaterNet.

The paper builds on two unpublished papers, Wright et al. (2001) and Jonker and Van der Zaag (2010). This was enhanced by data from various reports to the Annual General Meeting, reports to the donors, an evaluation report by external evaluators, the Scopus publication database and some data from a tracer study commissioned by the WaterNet Secretariat.

2 Water Resources Management in Southern and Eastern Africa

Economic and social development requires reliable access to sufficient water sources of good quality. In regions where water availability is uneven both in time and in space, there is a need to effectively manage the water resources. Whereas many people do not yet enjoy access to safe water supply and basic sanitation, this may worsen in the absence of concerted action, as water is becoming scarcer (as measured in per capita terms) and increasingly vulnerable due to migration of people, pollution, extreme climatic variability and climate change. Managing water resources has become more critical than ever before.

Integrated Water Resources Management as an approach to management water resources gained prominence after the international conference on water in Dublin and the international environmental conference in Rio de Janeiro in 1992. The Southern African Development Community (a regional assemblage of states in Southern Africa similar to the European Union) in its effort to promote regional integration and facilitating cooperative management of the region's rivers, adopted the SADC Protocol on Shared Watercourses in 1995. The effective development and management of water resources in Southern and Eastern African countries was hampered by some institutional and legislative constraints as well as insufficient financial and human capacity to implement programmes and activities that were consistent with the IWRM concept; and thus the implementation of the protocol. Water management initiatives were typically split among different ministries. The fragmentation of responsibilities among sectoral ministries and administrative agencies hindered attempts to integrate water management activities. The management of water was often executed by government departments with little or no formal stakeholder participation. The cost of managing water was often coming from general government taxes because cost recovery was not aimed for. As budgets dwindled, maintenance of water infrastructure was disregarded. Legal instruments were often fragmented and some countries had water allocation systems that were intrinsically, or with the passage of time had become, inequitable. Monitoring systems were weak and constrained by insufficient human and technical capacity. Finally, ecological requirements were seldom considered (e.g. Swatuk, 2005).

To address the above challenges, several Southern and Eastern African countries have embarked on thorough water sector reforms. With the aim to better coordinate water management, legislation has been revised and administrative and institutional changes have been introduced. Also, an initiative started to address the resulting human and institutional capacity needs.

3 Capacity building needs for Integrated Water Resources Management

Ten years ago, Wright et al. (2001) argued that IWRM not only needed a favourable policy environment and institutional and legal setting, but also, essentially, required adequate understanding of the physical processes involved and of the multiplicity of societal water needs and interests, as well as effective decision-making that focuses not only the supply and allocation of water, but also on the demand side.

Those implementing this new mode of water management typically were thought to be teams of professionals trained in a mix of relevant disciplines. It was considered essential for decision-making processes that such teams would have good disciplinary expertise, and be able to organise effective communication among staff and between staff, stakeholders and policy-makers, and thus facilitate meaningful information exchange (Wright et al., 2001).

In order to address these requirements listed by Wright et al. (2001), albeit partially, it was proposed to invest in human resources through developing dedicated capacity building programmes. It was further acknowledged and emphasised that universities needed to continue to train specialists in relevant "conventional" water disciplines at undergraduate and postgraduate levels, while ensuring that the university curricula were kept up-to-date.

However, two constraints were identified. First, in Southern Africa the opportunities for postgraduate training in water-related disciplines were few, which jeopardised the expertise requirement. Second, a new type of water resource generalist was deemed necessary, for which in the year 2000 no suitable curriculum existed in Southern Africa.

This formed the basis for proposing a new postgraduate programme in Integrated Water Resources Management that would aspire to achieve two things: (1) through a broad foundation curriculum would expose disciplinary trained 1st degree holders to a wide spectrum of perspectives and to a

common conceptual water language; (2) through a suitable specialisation phase and a thesis research requirement, offer students the possibility to either further deepen their specialist expertise or develop their generalist knowledge and skills.

The WaterNet initiative thus wished to produce sufficient well-trained specialists as well as a new type of generalists in water resources. The latter were viewed as the brokers within the water sector, able to establish links between specialists in sector departments. Such generalists were expected to constitute the "middle-ground" in integrated water resources development and management. They would, first, have a broad understanding of central concepts of the key disciplines involved, including hydrology, hydrogeology, chemistry and engineering, but also ecology, resource economics, law and management science, as well as disciplines relevant to the transboundary dimension of water resources, such as international relations (Wright et al., 2001). These generalists would be expected to translate these integrative concepts relevantly and intelligibly to other (disciplinary) players. Reference can be made to bridging concepts such as "green" and "blue" water, and "virtual" water. These generalists would be equipped with the necessary skills to facilitate decision-making processes. They would be proficient in team work, communication, negotiation and conflict management, while some would specialise in decision support systems (Wright et al., 2001).

4 A short overview of the process of establishing WaterNet

The WaterNet concept was prompted by the SADC-EU conference on the Management of Shared River Basins held in Maseru, Lesotho, in May 1997, when ministers responsible for water of Southern Africa and Europe articulated the urgent need to "level the playing field" between riparian countries and thus the need to prioritise capacity building (Savenije and Van der Zaag, 2000).

The WaterNet initiative was presented at a large number of conferences and fora in Southern Africa, including during the SADC Water Weeks that were held in 11 countries in 1999 in preparation of the Southern African Vision for Water, Life and Environment in the 21st Century. WaterNet was subsequently endorsed by SADC and acknowledged by the Global Water Partnership. A large number (44) of institutions (university departments, training and research institutes involved in different aspects of water) were invited to express their interest. Eighteen institutions responded positively. WaterNet was formally founded during a workshop held in March 2000 in Victoria Falls, Zimbabwe, when the 18 founding member institutions agreed that WaterNet would be a membership organisation, operating through an annual general meeting, a steering committee, a secretariat and a Trust fund (Wright et al., 2001). By 2012, the membership of WaterNet had grown to over 65 member institutions from 15 Southern and Eastern Africa countries. WaterNet has been generously funded by the Dutch government through DGIS and the Swedish government through Sida.

In Victoria Falls it was decided that WaterNet would fulfil its capacity building mandate through the creation of a Masters in Integrated Water Resources Management, the development of short professional development courses and the establishment of a research programme focussing on the integrative aspects of water management (Fig. 1).

5 The WaterNet Master Degree Programme in Integrated Water Resources Management

The WaterNet Masters in Integrated Water Resources Management:

- is a general Master degree programme that offers a broad range of courses relevant to Integrated Water Resources Management; the intake is thus not limited to graduates with an engineering or natural science background;
- is a regional programme, where several WaterNet member institutions offer a limited number of course modules in the fields in which they have a comparative strength (Wright et al., 2001).

The degree comprises a coursework component (12 months) and a research component (6 months). Originally the coursework consisted of 10 modules in total , plus a capstone module to mark the end of the coursework. The capstone module is a multidisciplinary groupwork project on which students jointly work for 4 weeks. The first six modules are foundational, which are offered at the University of Dar es Salaam and the University of Zimbabwe. Thereafter students follow three modules belonging to one of six (now: seven) specialisations of their choice, and finally the capstone groupwork project, again at the University where the students started. In addition to the six foundational modules and the capstone module, the University of Dar es Salaam and the University of Zimbabwe also offered two elective modules that students choose from a basket of modules.

The six specialisations are:

- Hydrology (University of Dar es Salaam, Tanzania);
- Water Resources Management (University of Zimbabwe);
- Water and Land (University of Botswana);
- Water and Environment (University of Malawi);
- Water Supply and Sanitation (Polytechnic of Namibia);
- Water and Society (University of the Western Cape, South Africa).

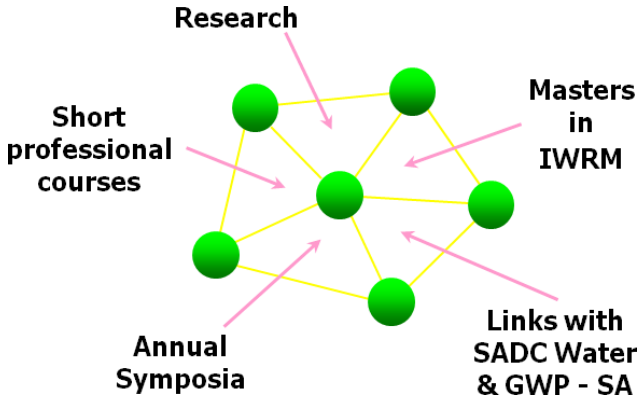

Fig. 1. WaterNet and its mutually reinforcing activities.

The process of getting this regional programme approved academically required creativity, regional commitment and pragmatism. The modality eventually agreed on was that:

- two universities would award the Master of IWRM degrees, namely the University of Dar es Salaam and the University of Zimbabwe, and both universities would approve identical curricula, including course modules that would not be taught on their own campuses, but elsewhere;
- these two universities would offer the core modules as well as one specialisation each;
- the other specialisations would be offered by other member universities with a comparative strength in that field;
- the University of Dar es Salaam and the University of Zimbabwe would accredit and accept the courses offered and examined and credits awarded by the other universities.

The implementation of the WaterNet Masters Programme in IWRM commenced at the two universities that hosted the core modules, the University of Dar es Salaam and the University of Zimbabwe, in October 2002 and February 2003, respectively. The other universities were subsequently encouraged to use the specialisation modules that they offered to the WaterNet programme as a basis for developing their fully-fledged and home-grown Masters programme by adding foundational modules, much in the same way as the University of the Western Cape was combining their own postgraduate programme in IWRM with the WaterNet specialisation in Water and Society (Jonker, 2005).

The WaterNet Board instituted a review of the Masters programme in 2006. The review report was accepted by the AGM in 2009 and an extensive curriculum review process was started in February 2010. This has resulted in the inclusion of a seventh specialisation (GIS and Earth Observation) and a change in the overall structure of the programme. Offering the electives became problematic because of the large number of options as opposed to the number of students. Often there was one student wanting to take an elective module. The electives were removed from the curriculum with one module being added to the specialisation (increase from three to four) and the second elective added to the foundational core. The new curriculum structure from 2012 is depicted in Fig. 2.

Increasing the number of modules in the core allowed for the addition of GIS and database management and water quality to the foundation. All the universities that offer part of the Masters programme contributed to aligning the content of the core modules as to form a coherent cluster. The reconceptualization that is required in the specialisation with the addition of an extra module, however, was left to the host institution. To date some uncertainty exists on whether this has happened. The restructuring of the curriculum, especially the addition of a seventh specialisation, raises the question that with so many specialisations, are we not introducing a new sectoral approach based on new categories and with that losing the integration that was strived for when the programme was initiated.

6 Research and outreach

WaterNet does more than offer a joint and regional Masters programme. It is also involved in other activities that are closely linked and that strengthen each other. First, the modular Masters in IWRM creates the opportunity to offer a comprehensive set of short professional courses. Second, it assists member institutions to develop interdisciplinary research programmes and activities that not only provide thesis research subjects and opportunities for students, but that also generate new findings that are fed back into the curricula. Third, the research outcomes are presented at symposia co-organized by the Water Research Fund of Southern Africa (WARFSA), a fund that has since folded, and the Global Water Partnership – Southern Africa (GWP-SA). These annual symposia provide a platform where water researchers, professionals and policy makers exchange ideas and set agendas.

The WaterNet Masters programme in IWRM includes a research project of six months' duration. There are thus significant opportunities for synergies with research programmes in which member institutions and staff are involved, and in which WaterNet has often played a facilitating and catalysing role. Two examples where WaterNet has played such a leading role are:

- "Integrated Water Resources Management for Improved Rural Livelihoods in the Limpopo River Basin" (Limpopo PN17) one of the basin projects of the Challenge Programme on Water for Food which ran from 2005 through 2010 and which was CGIAR funded. See

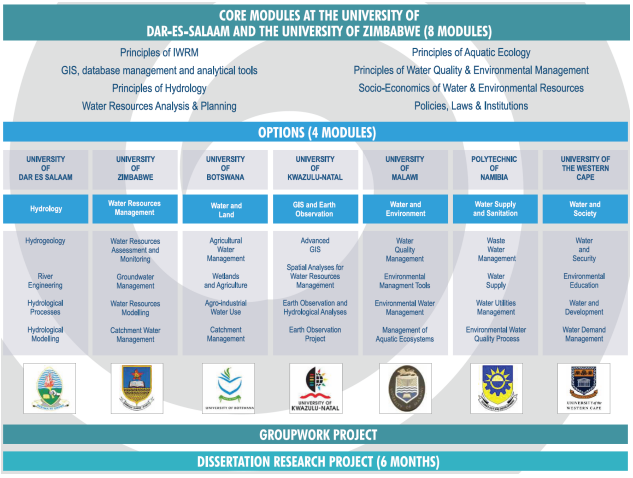

Fig. 2. New structure of the regional Master programme in IWRM, as at 2012.

Supplement and, e.g. Love et al. (2006). WaterNet is now involved in a successor project in the Limpopo Basin (Beukman et al., 2011; Kileshye-Onema et al., 2011);

– "Smallholder System Innovations in Integrated Watershed Management project in the Pangani Basin (Tanzania) and Thukela Basin (South Africa)" (SSI). This multidisciplinary programme ran from 2004 through 2010, was funded by Swedish (Sida) and Dutch (WOTRO and DGIS) sources. See Rockström et al. (2004), Bhatt et al. (2006) and Bossio et al. (2011). Currently a smaller successor project is still ongoing.

In these and other research programmes throughout SADC, several WaterNet member institutions are the main implementers. Both projects involve many different disciplinary experts (from hydrology to governance, from agronomy to ecology), maintain links with local agricultural research institutes, local water agencies and rural development NGOs. In both programmes the researchers work closely with farmers and practitioners, many experiments having been conducted on farmers' fields by and with the farmers, which helps to ensure that the research results are relevant to the livelihoods of rural communities.

7 Successes

The WaterNet programme claim some success in contributing to capacity building in IWRM in Southern and Eastern Africa. In this section we provide some data with respect to education, professional courses and capacity building programme, research, and finally the annual symposia.

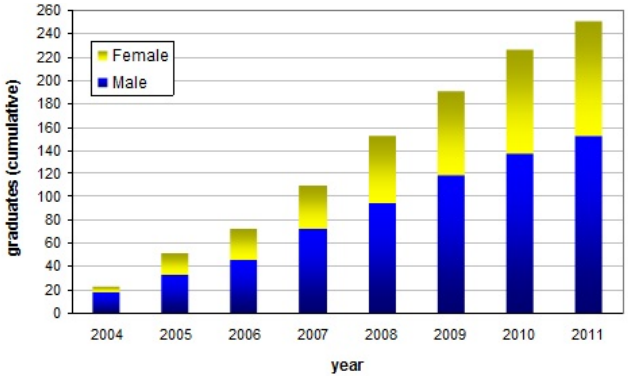

Fig. 3. WaterNet Master in IWRM graduates, 2004–2011.

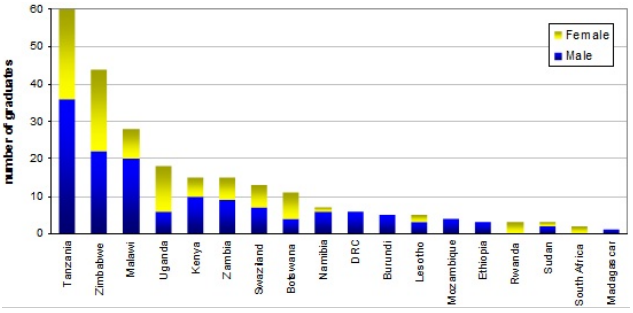

Fig. 4. Nationalities of WaterNet IWRM graduates, 2004–2011.

7.1 Education

Between 2003, when the WaterNet Master in IWRM programme was launched, and 2011, 251 students in total have graduated, of whom 99 (39 %) are female (Fig. 3). This also means that 251 Master theses on water related topics were produced.

One of the four Dublin Principles (which forms the philosophical basis of IWRM) states that "Women play a central part in the provision, management and safeguarding of water" (GWP, 2000). The important role that women play in water management at the grassroots level is acknowledged by stakeholders in the region. From this acknowledgement, it is then argued that the importance should be reflected in the number of women in formal water management positions. Hence the explicit mention of the number of women who have graduated.

The number of graduates comes from eighteen African countries (Fig. 4).

The relatively low numbers from Burundi, Ethiopia, Rwanda, Sudan, South Africa and Madagascar is because students from these countries started to apply for admission more recently. Initially, the bulk of the students came from Tanzania and Zimbabwe. This can be explained by the fact that universities from these two countries hosted the full Masters programme and as a result the programme was better

Table 1. Output of two large WaterNet affiliated multidisciplinary research projects

Output	SSI (2004–2009)	Limpopo PN17 (2006–2011)
Bachelor projects/theses	0	13
Master theses	19	40
PhD theses	6	3 (+3 in progress)
Papers in international peer-reviewed journals	34	41

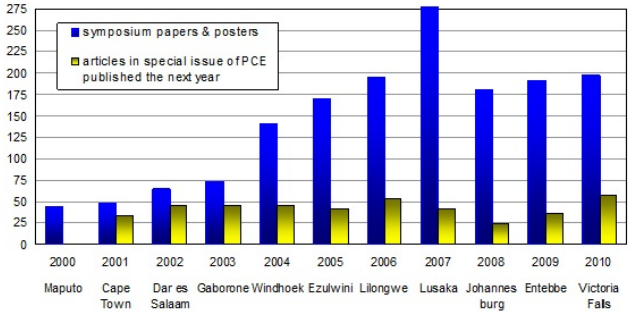

Fig. 5. Symposium papers and posters presented at the annual WaterNet Symposia, and the number of papers published in the annual special issue of *Physics and Chemistry of the Earth*.

known within the two countries than the rest of the region and this resulted in higher number of applicants. As the programme unfolded, the WaterNet Secretariat used the fellowship fund to balance the numbers admitted from other countries.

Anecdotal evidence seems to suggest that of the WaterNet alumni, more than 90 % are still professionally active in the region. The majority are employed by government institutions and parastatals, followed by the private sector, including multinational companies and universities; also many alumni are employed by local and international NGOs. Several graduates have pursued their academic education with PhD research, at a variety of universities in the region and beyond; most of them are still active in WaterNet and related activities, such as the WaterNet alumni association. This needs to be validated by a comprehensive tracer study.

7.2 Professional courses and capacity building programmes

WaterNet has trained 737 water professionals (32 % women) through 36 professional short courses over the period 2002–2011. WaterNet is recognised by SADC and features in its Regional Strategic Action Plans on Integrated Water Resources Development and Management (RSAP2 and RSAP3). WaterNet is also responsible for the SADC-EAC (East African Community) capacity building programme on sustainable large water infrastructure and is in the process of

Table 2. Citations of articles published in the WaterNet/WARFSA Special issues of Physics and Chemistry of the Earth, 2002–2011. Based on Scopus (www.scopus.com), consulted January 2012.

Special issue (year of publication)*	No. of articles	Citations (January 2012)	Average citations per article
2002	33	304	9.2
2003	46	432	9.4
2004	45	363	8.1
2005	46	359	7.8
2006	42	256	6.1
2007	53	274	5.2
2008	42	165	3.9
2009	24	75	3.1
2010	35	32	0.9
2011	57	1	0.0
	423	2261	5.3

* The special issue is published around October each year.

Table 3. The articles published in the WaterNet special issues of *Physics and Chemistry of the Earth* (2002–2010) represent a significant share of all scientific papers on water-related issues in Africa. Based on Scopus (www.scopus.com), consulted January 2012.

	WaterNet 2002–2010 (366 articles)	entire Scopus database 2002–2010	WaterNet's share
"water supply" and "Africa" in title, keywords and abstract			
no. of articles	123	1564	7.9 %
no. of citations	821	9865	8.3 %
cites per article	6.7	6.3	
"hydrology" and "Africa" in title, keywords and abstract			
no. of articles	96	653	14.7 %
no. of citations	710	7357	9.7 %
cites per article	7.4	11.3	
"water resources" and "Africa" in title, keywords and abstract			
no. of articles	213	1350	15.8 %
no. of citations	1348	8210	16.4 %
cites per article	6.3	6.1	
"water management" and "Africa" in title, keywords and abstract			
no. of articles	181	1173	15.4 %
no. of citations	1241	5263	23.6 %
cites per article	6.9	4.5	

negotiating the Zambezi Watercourse Commission's capacity building programme and support for the shared watercourses programme for the Save, Busi and Ruvuma basins. One can argue the number of attendees points to a success for WaterNet in contributing to capacity building of a different target audience as that for the Masters programme. However, there still needs to be an assessment of the change in water management practices that flows from attendance of the WaterNet training courses.

Table 4. Articles that address selected targets of the MDGs, and published in the WaterNet/WARFSA Special issues of Physics and Chemistry of the Earth, 2002–2011.

Primary theme addressed by article	MDG-related target	Articles	
Editorial	n/a	12	3 %
Hydrology		64	15 %
Water and environment	MDG 7, Target 9	83	20 %
Water, land and food	MDG 1, Target 2	79	19 %
Water for people (water and sanitation)	MDG 7, Target 10	74	17 %
Water and society, incl. governance	MDG 8, Target 12	37	9 %
Water resources management		74	17 %
Sum		423	100 %

7.3 Research

The research programmes in which WaterNet has played and continues to play a facilitating or leading role, have provided good opportunities for students to conduct project and thesis research and for staff to produce research papers (Table 1).

Another key aspect of such multidisciplinary research programmes was that WaterNet started learning to build partnerships outside the university sector: with CG centres, government departments and NGOs. Many of these partnerships continue beyond the project period. This has also led to cross-fertilisation and benefits to university curricula, other research initiatives and so on. The fact that WaterNet as a network developed a winning concept note and proposal for the Limpopo PN17 partnership, and subsequently showed it could successfully manage such a big and complex project, facilitated its member institutions getting access to international research programs. As an example, WaterNet leads the southern African component of the EC Framework Programme 7 project DEWFORA, which aims to improve drought early warning and forecasting throughout Africa.

7.4 Symposia

Combining tertiary education with research has thus proven powerful. Many WaterNet graduates have contributed new insights into various aspects of hydrology, water engineering and management, some of which have been presented at the WaterNet/GWP-SA symposia held annually since 2000, and published each year in a special issue of the journal *Physics and Chemistry of the Earth*. By the end of 2011 ten special issues had been published, containing more than 420 research papers (Fig. 5).

Importantly, these papers are frequently being cited (Tables 2 and 3). Of all papers cited on "water management" and "Africa", nearly a quarter are WaterNet papers. For hydrology this figure is lower (nearly 10 %), but still significant (Table 3). It should be realised that without WaterNet some of these papers would never have been published and could therefore never have been part of the global body of knowledge. In addition, these research papers address real-life issues that are of great concern for Southern Africa, and a significant number address issues related to the Millennium Development Goals (Table 4).

8 Summary and conclusion

The WaterNet network started as a project in 1999. It has evolved into an independent partnership organization. The WaterNet Trust oversees, the secretariat coordinates and most activities are delivered by WaterNet members and partners. It is well-embedded institutionally. Starting as a project recognised by SADC, and based on what it has achieved during the last ten years, WaterNet is expected to become a SADC Subsidiary Institution in 2012. It is this legitimate ownership and accountability structures that contributes to WaterNet being an effective regional capacity building network. Members trust its structure and organisation; they are given the opportunity to question and to contribute to policy and operations at the Annual General Meeting. In addition to member commitment, having a competent and adequately funded secretariat to coordinate and manage the affairs of the network seems critical, because jointly developing educational programmes by sharing expertise and resources requires intense intellectual management and sufficient financial means.

The demands of modern day water resources management makes it virtually impossible for poor countries to have all the capacities required to train water professionals to fulfil all water management functions. Connecting institutions within a region makes sense because they can pool their resources, which is especially important for the smaller countries. Knowledge capacities can be spread and shared, which contributes to greater equity and is more cost effective. Adopting a regional approach makes sense because water has a transboundary dimension. The fact that students from different countries sit in the same class and learn the same concepts enhances mutual respect and understanding; and that they move around in the region gives them a regional perspective (Van der Zaag, 2009b; Van der Zaag et al., 2009). This will hopefully encourage future cooperation on water,

and may be considered a prudent investment in future cooperation, peace and stability.

WaterNet has made a first significant step towards the creation of a community of practice comprising educators, researchers, policy makers, students and practitioners that is characterised by a strong connectivity, the sharing of resources and distributed access to knowledge (Van der Zaag, 2009a). These are the ingredients for this community to frame, reflect on, and define its own problems and find novel ways to resolve them – and hence to learn and grow. The sharing of knowledge is a key success factor, as is the keenness of academics to present papers at symposia. At first, many lecturers hesitated to write papers because there were more urgent issues to attend to, but this has changed over time. Since 2009 the symposia have received over 150 abstracts each year. In addition to researchers and lecturers, the symposium is attended by policy makers and practitioners. Here these stakeholders see the value of sharing data, information and knowledge. Connecting people in this manner makes sense because the perceived need for confidentiality of data and information could be challenged and mediated.

Finally, it should be observed that without the trust and long-term commitment from donor organisations that appreciate and acknowledge the value and benefit of knowledge sharing, the WaterNet experience could never have evolved from an innovative experiment into a recognised regional institution with a tangible impact.

Supplementary material related to this article is available online at: http://www.hydrol-earth-syst-sci.net/16/4225/2012/hess-16-4225-2012-supplement.pdf.

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References

Beukman, R., Takawira, A., Kileshye-Onema, J.-M., Love, D., Cofie, F., Amede, T., and Sullivan, A.: Enhancing impact in Africa: A CPWF platform for knowledge and experience sharing in research and implementation for development, 3rd International Forum on Water and Food, November, Tshwane, South Africa, 2011.

Bhatt, Y., Bossio, D., Enfors, E., Gordon, L., Kongo, V., Kosgei, J. R., Makurira, H., Masuki, K., Mul, M., and Tumbo, S. D.: Smallholder system innovations in integrated watershed management (SSI): Strategies of water for food and environmental security in drought-prone tropical and subtropical agro-ecosystems, IWMI Working Paper 109, International Water Management Institute, Colombo, 2006.

Bossio, D., Van der Zaag, P., Jewitt, G., and Mahoo, H. (guest Eds.): Smallholder Systems Innovations for Integrated Watershed Management in Sub-Saharan Africa, Special issue, Agr. Water Manage., 98, 1683–1774, 2011.

Dzingirai, V. and Manzungu, E.,: Towards an institutional model for water resources management, 10th WaterNet/WARFSA/GWP-SA Annual Symposium, Uganda, 2009.

GWP: Integrated Water Resources Management, TAC Background Paper No. 4. 2000.

Jonker, L.: IWRM: What should we teach? A report on curriculum development at the University of the Western Cape, South Africa, Phys. Chem. Earth, 30, 881–885, 2005.

Jonker, L. and Van der Zaag, P.: A regional and multi-faceted approach to postgraduate water education: the WaterNet experience in Southern Africa. Paper presented at the seminar "Collaborate to Innovate", 8–10 November, University of the Western Cape, Bellville, Cape Town, South Africa, 2010.

Kileshye-Onema, J.-M., Love, D., Sullivan, A., and Takawira, A.: Research for impact, an approach on capacity development from the Limpopo Basin, 3rd International Forum on Water and Food, November, Tshwane, South Africa, 2011.

Love, D., Twomlow, S., Mupangwa, W., Van der Zaag, P., and Gumbo B.: Implementing the millennium development food security goals – Challenges of the southern African context, Phys. Chem. Earth, 31, 731–737, 2006.

Rockström, J., Schulze, R., Folke, C., Gordon, L., Hatibu, N., Jewitt, G., Penning de Vries, F., Rwehumbiza, F., Sally, H., Savenije, H. H. G., and Schulze, R.: A watershed approach to upgrade rainfed agriculture in water scarce regions through Water System Innovations: An integrated research initiative on water for food and rural livelihoods in balance with ecosystem functions, Phys. Chem. Earth, 29, 1109–1118, 2004.

Savenije, H. H. G. and Van der Zaag, P.: The Maseru Conference, Water Policy, 2, 1–7, 2000.

Swatuk, L. A.: Political challenges to implementing IWRM in Southern Africa, Phys. Chem. Earth, 30, 872–880, 2005.

Van der Zaag, P.: Sharing knowledge for water sharing, Irrig. Drain., 58, S177–S187, 2009a.

Van der Zaag, P.: Thinking out of the ordinary – promoting knowledge generation and research on water, in: Water for a changing world – developing local knowledge and capacity, edited by: Alaerts, G. J. and Dickinson, N. L., CRC Press/Balkema, Leiden, 163–178, 2009b.

Van der Zaag, P., Gumbo, B., Gunawardena, E. R. N., Khan, S., Kitaka, N., O'Keeffe, J., Rap, E., Uhlenbrook, S., and Van Dam, A. A.: Climate, energy and environmental care: Investigating new collaborative research approaches, Chapter 10, in: Knowledge on the Move: Emerging Agendas for Development-oriented Research, edited by: Molenaar, H., Box, L., and Engelhard, R., International Development Publications, Leiden, 195–222, 2009.

Wright, E. A., Savenije, H. H. G., and Van der Zaag, P.: The development of a collaborative Master degree programme in integrated water resources management in Southern and Eastern Africa, Proceedings 7th Annual Intl. Conference on Engineering Education "Progress through Partnership – Strengthening alliances", 6–10 August, Oslo, 7D7, 13–18, 2001.