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HESS Opinions
"Urgent water challenges are not sufficiently researched"

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Abstract

In this opinion paper we submit that water experts conduct comparatively little research on the more urgent challenges facing the global community. Apparently there is a mismatch between the global demand for knowledge and the finance for and supply of knowledge. This mismatch is identified here as a problem that we water scientists must try to confront and resolve. We need to understand why this mismatch occurs and persists, in order to find ways to break out of the impasse. Although this paper addresses a critical challenge it does not aim to be exhaustive or definitive. We merely identify the persistence of intransigent water problems as a research object in itself.

1 Introduction

What are the urgent water challenges that the world faces? There is certainly no lack of authoritative global assessments that articulate pertinent water challenges. Among these assessments are the UN Development Reports (UNDP, 2006; UNDP, 2007), reports related to the Millennium Development Goals (e.g. UN, 2005; UN Millennium Project, 2005), the Biennial Report on Freshwater Resources (Gleick, 2008), and the tri-annual World Water Development Reports (UNESCO, 2006). Other important documents are regularly produced by the FAO on food and food insecurity (FAO, 2008a, b), by the Intergovernmental Panel on Climate Change on, inter alia, climate change and water (Bates et al., 2008), and by the World Resources Institute (WRI, 2008). The Millennium Ecosystem Assessment (2005) and the Comprehensive Assessment of Water Management for Agriculture (Molden, 2007) also discussed key water issues.

These reports continuously formulate and re-formulate challenges that are all variations and specifications of a limited set of problems, many of which having a significant water dimension. The most important of these water problems may be summarised as follows:

1. *Sanitation:* Whereas access to potable water for all remains a formidable chal-

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lenge, an even greater challenge is to ensure adequate sanitation for all. Forty percent of humanity remains without access to adequate sanitation services, and this percentage is proving difficult to bring down. Sanitation directly influences human health and productivity, especially in densely populated areas. Moreover, lack of proper sanitation is frequently associated with environmental degradation.

2. *Food security:* Many households remain food insecure. Crop yields have to increase, also in order to feed an ever-growing population. Many smallholder farmers, especially in Sub-Saharan Africa, do not manage to achieve grain yields above 1.5 tons per hectare, and due to variability of rainfall harvests regularly fail, directly affecting livelihoods. Soil nutrients and water are limiting factors that can, however, be overcome (Falkenmark and Rockström, 2004).

3. *Freshwater ecosystem integrity:* Economic development is accompanied by environmental externalities. Resource use leads to over-abstraction of water from rivers and aquifers, to pollution of air, water and soil, and has completely modified hydrological regimes. This negatively affects the integrity of ecosystems, which is not only detrimental to plant and animal life, but also to human beings, as humans rely on ecosystem services for their livelihoods and recreation.

4. *Adaptation to climate change:* There is an urgent need to enhance the capacity of water systems to respond to the potential impacts of climate change, such as increased variability of rainfall, increased intensity and frequency of extreme events, and, in many parts, a decrease in the utilisable amounts of surface- and groundwater.

5. *Governance:* Where there are problems of water scarcity, sanitation, food security, water pollution or extreme events, tensions arise between rival water users (and rival water uses) and between rival uses of scarce government resources. These problems occur at different levels of governance, in rural and urban areas, involving individual actors, communities, and nation states. Developing legitimate

institutions that adequately deal with such dilemmas and potentially conflictive situations is a major scientific and political challenge. Given the global trends of change, such situations are likely to occur more frequently and in more intense forms in future requiring more responsive governance systems.

Are we water scientists contributing sufficiently to resolving the above challenges? The answer is straightforward: we don't. This we can prove with bibliometric data on the research output in the field of water. This analysis is based on data from ISI Web of Knowledge (http://isiwebofknowledge.com).

2 Research in the field of water is heavily biased against sanitation

Research in the field of water is heavily biased against sanitation and this may explain why so little progress is made on this issue (Table 1). But this is of great concern given the current sanitation crisis. The sanitation crisis is a three sided problem: it severely compromises human health; it creates severe pollution loads and thus impacts the environment negatively; and it represents a waste of rapidly depleting nutrients that could be a resource for food and/or energy production. Of the small research output on sanitation, most comes from developed countries, and few research subjects are initiated, carried out and published by knowledge institutions in the global South (Table 2). This comes as no surprise since in countries where sanitation needs are largest the number of research and development experts is lowest, and hence the capacity to develop home-grown solutions is constrained (Gupta and Van der Zaag, 2009). This is a relevant observation since sanitation practices are influenced by locally specific biogeochemical, socio-economic, cultural and institutional aspects. Yet, compared to bibliometric statistics on some other water topics (see next sections), the contribution on sanitation research by developing countries is not negligible (above 10%).

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3 Research on food security is biased in favour of conventional irrigation, and fails to address the problems and opportunities of rainfed agriculture

There are five times more research papers on irrigation that do not take rainfed agriculture into account than there are papers that address both issues or that only address rainfed agriculture (Table 3). This is remarkable considering that so many more people depend on rainfed agriculture for their livelihood than on irrigation, and despite the social, economic and health problems associated with low crop yields of rainfed agriculture in many semi-arid tropical and sub-tropical regions. It is interesting to note that the share of developing countries and countries in transition contributing papers on rainfed agriculture is large (44.7%, see Table 4).

4 Insufficient water research is dedicated to developmental compared to environmental issues

Poor sanitation and food insecurity are both associated with poverty, but there are no simple cause-effect relations: are people poor because they lack access to adequate sanitary services or is it the other way around? Low crop yields certainly contribute to the vulnerability of rural livelihoods, but are higher and more secure crop yields a sufficient condition for rural people to extricate themselves out of poverty? In order to answer these questions, the complex dynamics that exist between poverty, livelihoods, infrastructure, institutions, and access to natural resources and essential services must be considered. Socio-economic development is both a result of *and* a prerequisite for resolving the sanitation and agricultural challenges. Eradicating poverty is therefore the central Millennium Development Goal. Without broad-based economic development most of the other development goals, as well as the water, sanitation, maternal health and food security targets, are not achievable.

There will be environmental consequences, both positive and negative, associated with such broad-based socio-economic development. These ecological concerns ob-

viously merit attention, but given the urgency of the water problems identified, it is expected that the research output on developmental (economic) issues in a water context would be of the same order, or larger, than that on environmental (ecological) issues.

To verify this hypothesis we compared the number of research papers on water and economic development with those on water and the environment. According to the ISI Web of Knowledge database, three times more papers deal with the latter and these are cited much more frequently (Table 5). Remarkably, less than 1% of all papers mention both issues. Scientists from developing countries contribute a negligible number of papers concerning water and environmental issues but author significantly more research papers dealing with water and economic development (Table 6).

5 Too little research is conducted on adaptation to climate change by developing countries

It is widely acknowledged that climate change will hit developing countries hardest. Not only because the impacts on the sub-tropical and tropical areas will be more severe than in the temperate zones, but also because the climate change impacts come over and above the existing challenges that these countries already face in terms of meeting basic needs, and because these countries generally lack sufficient capacity (human, knowledge, capital, institutional, etc.) to adapt. This is reflected in the bibliometric data: developing countries contribute a negligible amount of papers on adaptation to and mitigation of climate change. The countries that are primarily responsible for climate change themselves are confident that they can develop sufficient adaptive capacity, and dominate the scientific output, both on mitigation and adaptation strategies for climate change (Tables 7 and 8).

The climate change challenge that developing countries face is exacerbated by the recent and sudden increase in biofuel demand as a result of the EU and USA seeking to mitigate their greenhouse gas emissions and to reduce their dependency on oil exporting countries. As biofuel production competes with existing uses of land and water

resources, the North partly externalises its biofuel demands to the South. But also in the South, biofuel production competes with existing land and water uses. This leads to policy dilemmas in many developing countries: between export-led development versus livelihood security scenarios. Yet Table 8 shows that these countries have limited research capacity to critically analyse these dilemmas and propose appropriate policies. The huge land and water concessions that European and American investors, fuelled by interesting subsidy schemes, are currently acquiring in countries such as Ethiopia, Mozambique, Peru and Tanzania for establishing large biofuel plantations pinpoint at weakly developed and/or weakly respected resource rights of local communities, especially land rights (Keyzer et al., 2008) and water (our own observations). The water dimension, however, receives too little attention (Uhlenbrook, 2007).

6 Research on water governance has a fascination for conflict but too little eye for cooperation

Tensions arise where problems of water scarcity, sanitation, food security, water pollution or extreme events occur. What type of research is required to prepare ourselves to deal with increasingly fierce competition over water between rival water users that seems inevitable in the near future? Table 9 shows that there is a clear fascination in the literature for water conflict, as there are many more research papers that mention water conflict in their title than there are papers on water cooperation. Conflict rightfully attracts attention and requires to be understood before it may be resolved. But the fact that there is more talk and thought about water conflict than about water cooperation may have a self-fulfilling effect. Is this focus on conflict sufficient to better understand how to share water peacefully? It is in our view urgent to better understand why water is often a factor of collaboration between communities, nations and people. This insight can help us build stronger and robust water sharing arrangements between user groups that all have legitimate claims to scarce water. Institutions can indeed be viewed as systems that manage conflict (NWO, 2007), but it may be more plausible to

consider them as arrangements meant to build and sustain cooperation.

7 Conclusions

This opinion paper has demonstrated the following. First, that research in the field of water and sanitation is heavily biased against sanitation. Second, that research on food security is biased in favour of conventional irrigation, and fails to address the problems and opportunities of rainfed agriculture. Third, insufficient water research is dedicated to developmental compared to environmental issues. Fourth, too little research is conducted on adaptation to climate change by developing countries. And finally, research on water governance has a fascination for conflict but too little eye for cooperation and meeting basic needs.

The pertinent global water related problems thus remain under-researched. The lack of knowledge on these problems is clearly sub-optimal and very costly in human, social, economic and political terms.

Furthermore, the innovation potential of inter-disciplinary research remains underutilized. Overcoming the disciplinary biases that we all have (if there is a water problem water engineers tend to prescribe pipes, water lawyers rights, and water economists correct prices) may open up new possibilities. Progress is likely when disciplines are crossed and combined. Interdisciplinary and integrated approaches are, however, not obvious, especially since many epistemic and institutional obstacles need to be overcome. One clear example is that at this moment there are no leading academic journals that can rightfully claim to adequately cover the (admittedly ill-defined) inter-disciplinary field of integrated water resources management.[1]

[1]The impact factor of Water Resources Management is relatively low (IF=0.79). Water Policy has only recently been admitted as an ISI journal, and no impact factor is available. The International Journal of Water Resources Development recently lost its ISI recognition. The Journal of River Basin Management is a relatively new journal seeking ISI recognition. Water International has an IF of only 0.37. There are two journals with a considerable academic repu-

The imbalance in research confirms that science reflects the socio-economic global divide (Annan, 2003; UNESCO, 2005) and is the result of the geographical imbalance of research capacity and research funding. If this is true, then the only way to contribute to a more balanced research agenda is to prioritise the strengthening of research capacity in the global South. There are encouraging signs that the share in scientific output of Latin American countries as well as the newly industrialised countries in Asia is rapidly increasing. But research output in other regions remains stagnant, notably Sub-Saharan Africa, the Arab States, Central and Eastern Europe and parts of Asia (UNESCO, 2005). It is precisely in these regions where major water challenges remain unresolved. It is here where research partnerships with other water scientists from the South (South-South cooperation) and with colleagues from the global North (South-North cooperation) could make a difference.

There are several regional examples of successful South-South-North academic partnerships that are starting to make significant contributions to pertinent water issues. Among these are Concertación in the Andean countries in Latin America (Rap, 2008), Crossing Boundaries in South Asia (Gunawardena, 2008), and WaterNet in Southern Africa (Nyabeze, 2007). Scientific evidence of such successes is, however, not sufficiently documented (but see Van der Zaag, 2007).

Elsewhere we have argued that the South should be allowed and enabled to create its own research biases (Gupta and Van der Zaag, 2009). This would enhance the diversity in research experiments and hence the chances of developing innovative and alternative solutions. One practical way of promoting research capacity is through establishing “regional water research funds”. Such regional research funds are well placed to promote research capacity and create institutional spaces where regional research agendas are defined, implemented, reviewed and refined (Van der Zaag, 2009).

tation on water management, namely Journal of Water Resources Planning and Management-ASCE (IF=1.03) and Journal of the American Water Resources Association (IF=1.436), but both journals do not claim to represent the full breath of the IWRM field.

To begin to address the observed weaknesses in our scientific practice, we scientists must start to acknowledge the biases in our own research work, and try to understand the mechanisms that influence it. In so doing we can meaningfully contribute to a more balanced research agenda that genuinely addresses the great water challenges, including improved sanitation, increasing crop yields in rainfed agriculture, restored ecosystem health and the creation of more robust and adequately governed water systems.

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Table 1. Scientific papers on water supply and drinking water versus sanitation, 1998–2007.

search term in title, keywords and abstract	Papers
water AND (supply OR drinking) NOT sanitation	30 686
water AND sanitation NOT (supply OR drinking)	603
water AND (supply OR drinking) AND sanitation	366
	31 655

Source: http://isiwebofknowledge.com.

Table 2. Location of the institution of authors of scientific papers on sanitation, 1998–2007.

water AND sanitation NOT (supply OR drinking)		water AND (supply OR drinking) AND sanitation	
developed countries	72.3%	developed countries	59.6%
countries in transition	16.5%	countries in transition	24.5%
developing countries	11.2%	developing countries	15.8%

Source: http://isiwebofknowledge.com.

Table 3. Scientific papers on rainfed and irrigated agriculture, 1998–2007.

search term in title, keywords and abstract	papers	citations	citation average	H-index
water AND “irrigated agriculture” NOT “rainfed agriculture”	333	1858	5.6	28
water AND “rainfed agriculture” NOT “irrigated agriculture”	62	426	6.9	11
water AND “irrigated agriculture” AND “rainfed agriculture”	8	35	4.4	3
	403	2319	5.8	

Source: http://isiwebofknowledge.com.

Table 4. Location of the institution of authors of scientific papers on rainfed and irrigated agriculture, 1998–2007.

water AND "irrigated agriculture" NOT "rainfed agriculture"		water AND "rainfed agriculture" NOT "irrigated agriculture"	
developed countries	73.3%	developed countries	55.3%
countries in transition	16.8%	countries in transition	27.6%
developing countries	9.9%	developing countries	17.1%

Source: http://isiwebofknowledge.com.

Table 5. Scientific papers on ecology and environment and on development and economy, 1998–2007.

search term in topic title, keywords and abstract	papers	citations	citation average	H-Index
water AND ecology AND environment NOT (development AND economy)	869	11 395	13.1	44
water AND development AND economy NOT (ecology AND environment)	288	2048	7.1	22
water AND development AND economy AND (ecology AND environment)	8	52	6.5	4
	1165	13 495	11.6	

Source: http://isiwebofknowledge.com.

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Table 6. Location of the institution of authors of scientific papers on ecology and environment, and on development and economy, 1998–2007.

water AND ecology AND environment NOT (development AND economy)		water AND development AND economy NOT (ecology AND environment)	
developed countries	83.2%	developed countries	66.2%
countries in transition	15.3%	countries in transition	26.7%
developing countries	1.5%	developing countries	7.1%

Source: http://isiwebofknowledge.com.

Table 7. Scientific papers on climate change, adaptation and mitigation, 1998–2007.

Search terms in title, keywords and abstract	papers	citations	citation average	H-index
climate change AND adaptation NOT mitigation	837	10 666	12.7	46
climate change AND mitigation NOT adaptation	565	5694	10.1	33
climate change AND mitigation AND adaptation	118	1192	10.1	16
	1520	17 552	11.5	

Source: http://isiwebofknowledge.com.

Table 8. Location of the institution of authors of scientific papers on climate change, adaptation and mitigation, 1998–2007.

climate change AND adaptation NOT mitigation		climate change AND mitigation NOT adaptation	
developed countries	90.0%	developed countries	85.3%
countries in transition	8.6%	countries in transition	13.0%
developing countries	1.4%	developing countries	1.6%

Source: http://isiwebofknowledge.com.

Table 9. Scientific papers on water conflict and water cooperation, 1998–2007.

Search term in title	papers	citations	citation average	H-index
water AND conflict NOT cooperation	91	317	3.5	8
water AND cooperation NOT conflict	30	96	3.2	6
water AND cooperation AND conflict	11	28	2.5	4
	132	441	3.3	

Source: http://isiwebofknowledge.com.

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