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INTEGRATED WATER RESOURCES MANAGEMENT: Constraints and opportunities with a focus on the Ganges and the Brahmaputra River Basins

Muhammad Mizanur Rahaman

Dissertation for the degree of Doctor of Science in Technology

HELSINKI UNIVERSITY OF TECHNOLOGY

Water & Development Research Group

Integrated Water Resources Management: Constraints and Opportunities with a focus on the Ganges and the Brahmaputra river basins

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Abstract: The key aims of this thesis are to identify the constraints and opportunities of implementing the integrated water resources management (IWRM) concept at both the policy and field level. IWRM has been chosen as a focus of this study as all contemporary international conferences, summits, regional water policies and declarations promote the IWRM concept for the effective and efficient management of water resources.

The thesis has two parts. The first part reviews the evolution of the IWRM concept and the principles that have been developed at international conferences over the last three decades. Through two case studies on the EU Water Framework Directive (2000) and the Fourth World Water Forum's Ministerial Declaration (2006), an attempt is made to analyse the current implementation status of IWRM principles in practice. The findings suggest that existing policies tend to take a rather narrow view of the concept and have largely failed to incorporate the principles. This part also identifies the seven future challenges in implementing IWRM in practice.

Water resources management is multidimensional in nature. In transboundary river basins, implementing the IWRM concept is even more complex as it involves more than one sovereign nation sharing the same water. The second part of the thesis focuses on implementation of IWRM in the transboundary river basin context. This part provides in-depth analyses focusing on the integrated management of the Ganges and Brahmaputra river basins that are shared by China, Nepal, Bhutan, India and Bangladesh. It identifies the various dimensions of water conflict among the riparian countries and their views on integrated management of the basins. It analyzes the existing bilateral treaties between the riparian countries and identifies the constraints and benefits of integrated water management along the basins. Practical recommendations for the integrated management of the Ganges and Brahmaputra basins are formulated. The findings suggest that it is imperative to coordinate all water related development plans and aspirations of riparian nations through effective transboundary cooperation to promote implementation of the IWRM concept in the Ganges and Brahmaputra basins. This thesis also identifies the principles associated with transboundary water resources management that are necessary to facilitate IWRM implementation in international river basins.

Water research and science play an important role in advancing the principles of IWRM and the implementation of the process. This thesis is an attempt to contribute to this process and facilitate integrated Ganges and Brahmaputra basins management.

Keywords: Integrated Water Resources Management, Principles, Implementation, EU Water Framework Directive, World Water Forum, Transboundary river basin, Ganges basin, Brahmaputra basin

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LIST OF APPENDED PUBLICATIONS

This thesis is based on the following Publications, which are referred to in the text by their Roman numerals.:

I: Rahaman, M. M. & Varis, O., 2005. Integrated Water Resources Management: Evolution, Prospects and Future Challenges. *Sustainability: Science, Practice and Policy*, 1: 15-21.

II: Rahaman, M.M., Varis, O. & Kajander, T., 2004. EU Water Framework Directive vs. Integrated Water Resources Management: The Seven Mismatches. *International Journal of Water Resources Development*, 20(4): 565-575.

III: Rahaman, M. M. & Varis, O., 2008. Mexico World Water Forum's Ministerial Declaration 2006: A Dramatic Policy Shift? *International Journal Water Resources Development*, 24(1): 177-196.

IV: Rahaman, M. M., 2009. Principles of International Water Laws: Creating Effective Transboundary Water Resources Management. *International Journal of Sustainable Society*. In Press. Accepted 10 November 2008. 17 pages.

V: Rahaman, M. M., 2009. Integrated Ganges Basin Management: conflicts and hope for regional development. *Water Policy*, 11(2):168-190.

VI: Rahaman, M. M., 2009. Principles of Transboundary Water Resources Management and Ganges Treaties: An analysis. *International Journal of Water Resources Development*, 25(1):159-173.

VII: Rahaman, M. M. & Varis, O., 2009. Integrated Water Management of the Brahmaputra Basin: Perspectives and hope for regional development. *Natural Resources Forum*, 33(1): 60-75.

AUTHOR'S CONTRIBUTION

Contribution of the author to Publications from I to VII is as follows:

I: The author of this thesis is responsible for the basic idea, planning the paper and review of the IWRM recommendations. The author is mainly responsible for identifying the challenges and writing the paper. Professor Varis wrote portions of the paper and provided comments during the writing stage.

II: The basic idea comes from the author and Professor Varis. The author is responsible for the profound review of the EU Water Framework Directive. The author is mainly responsible for the identification of the seven mismatches and writing of the paper. Professor Varis wrote portions of the paper and provided comments during the analysis of the results and the writing stage. Mr. Kajander assisted in writing portions of the paper.

III: The basic idea comes from the author. The author is responsible for planning the paper, analysing the policy documents, identification and interpretation of the findings and writing the paper. Professor Varis participated in writing the paper and provided comments during the writing stage.

IV: The author is fully responsible for the paper.

V: The author is fully responsible for the paper.

VI: The author is fully responsible for the paper.

VII: The basic idea comes from the author. The author is responsible for planning the paper, collection and analysis of data and information, interpretation of the results and writing of the paper. Professor Varis provided comments during the analysis of the results and the writing stage.

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Espoo, 30 April 2009

Muhammad Mizanur Rahaman

This work is dedicated to my Mother

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1 INTRODUCTION

1.1 BACKGROUND

Over the past decades, it has become obvious that water professionals, policy makers or water ministries alone can no longer resolve the water problems of a country or a river basin. The problems are too complex, interconnected and multidimensional to be handled by any one institution or one group of professionals. In the current century, water problems will continue to grow and become more acute and affect other development sectors like agriculture, energy, industry, environment and health. Water can no longer be viewed in isolation as a single resource, without the explicit and simultaneous consideration of other related development sectors, and vice-versa (Biswas, 2003). Hence, an integrated approach to water management is necessary for ensuring maximum benefits from the utilisation of the water resources.

Since the United Nations Conference on Water (1977), international water professionals, in alliance with all concerned stakeholders, have promoted the use of the Integrated Water Resources Management (IWRM) concept for effective and efficient management of water resources worldwide. The Technical Advisory Committee of the Global Water Partnership defined IWRM "as a process, which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems," and emphasized that water should be managed in a basin-wide context, under the principles of good governance and public participation (GWP, 2000; 2003). IWRM has been identified as one of the basic water resources management approaches in several recent important commitments, declarations and recommendations, such as those of Agenda 21, the World Summit on Sustainable Development (WSSD) (2002) and the World Water Forums.

In the WSSD Plan of Implementation (2002), the preparation of IWRM and water efficiency plans by 2005 for all major river basins of the world was one of the major water related targets. The need for IWRM is particularly urgent in the 263 river basins, which are shared by two or more states and in which nearly half of the territory and population of the world are located. International rivers basins account for 60% of all the water that flows in world's rivers. A total of 145 nations have shared waters with their neighbours (Wolf et al. 2003). Integrated planning for efficient river basin management is hampered by the difficulties of coordinating between riparian states with diverse and often conflicting needs (UNESCO & Green Cross International, 2003). Not only should policies and goals be developed, but so should practical frameworks based on agreed principles for implementing joint river basin management through efficient institutions and productive participation of all riparian states. Better theoretical understanding of the IWRM approach, associated principles and the existing water resources management challenges of a river basin is vital for implementing the IWRM concept and achieving efficient water management along the river basin.

1.2 STRUCUTURE OF THE DISSERTATION

The thesis comprises seven separate publications and this compendium of the publications summarising the objectives (section 1.3), methodologies (section 2) and results and

discussion (sections 3 and 4) of the research. Section 5 presents the concluding remarks of this summary.

1.3 OBJECTIVES

The overall objectives of this thesis can be divided into two sub-groups: a) identifying the constraints and opportunities of IWRM implementation at policy level (covered in Publications 1 to IV) and b) identifying the constraints and opportunities of IWRM implementation at field level (covered in Publications 1, IV to VII).

More specifically, this thesis has eight objectives. These are as follows:

1. Analysing the evolution of the IWRM concept and identifying the future challenges of its implementation (covered in Publication I).

2. Identifying IWRM principles and critically analysing the main outcomes of international water events focusing on IWRM (covered in Publications I, II and III).

3. Identifying the current implementation status of IWRM principles in practice (covered in Publications II and III).

4. Identifying transboundary water resources management principles that are necessary for promoting IWRM implementation in international river basins (covered in Publication IV).

5. Identifying various dimensions of water conflicts, water cooperation, future development plans and perspectives of riparian countries and impediments and benefits of IWRM in the Ganges river basin (covered in Publications V, VI and VII).

6. Analysing the existing bilateral treaties in the Ganges river basin in relation to the transboundary water recourses management principles identified in Publication IV (covered in Publication VI).

7. Analyzing the future development plans and perspectives of riparian countries and constraints and benefits of IWRM in the Brahmaputra river basin as Publication V shows it is relevant to achieve IWRM in the Ganges Basin (Publication VII).

8. Identifying key steps to be considered to facilitate IWRM implementation in the Ganges and Brahmaputra river basins and to promote regional development (covered in Publications V, VI and VII).

2 METHODOLOGIES

The methodologies used in the appended publications (I to VII) are elaborately described in each appended publication. The methodologies used are summarised in the following.

Publications I, II and III: Review and comparative analysis of the outcome, action plan, recommendations and declarations of the major international water events and policy tools related to the development of IWRM principles: United Nations Conference on Water (1977), International Conference on Water and Environment (1992), Chapter 18 of Agenda 21 (Rio de Janeiro, 1992), Second World Water Forum (2000), European Union Water Framework Directive (2000), International Conference on Freshwater (2001), World Summit on Sustainable Development (2002) and Third World Water Forum (2003), Fourth World Water Forum's Ministerial Declaration (Mexico, 2006). These studies also include literature reviews and scrutinizing international, regional and national water policies.

Publications IV and VI: Review and analysis of the scope of international legal tools and treaties related to transboundary water resources management principles: ILA Helsinki Rules (1966), United Nations Watercourses Convention (1997), Ganges Treaty (1996) and Mahakali Treaty (1996). These studies also include scrutinizing Indus Waters Treaty (1960), SADC Protocol on Shared Watercourse Systems (1995), Sava River Basin Agreement (2002), Mekong Agreement (1995), UNECE Water Convention (1992), ILA Berlin Rules (2004), Stockholm Declaration on

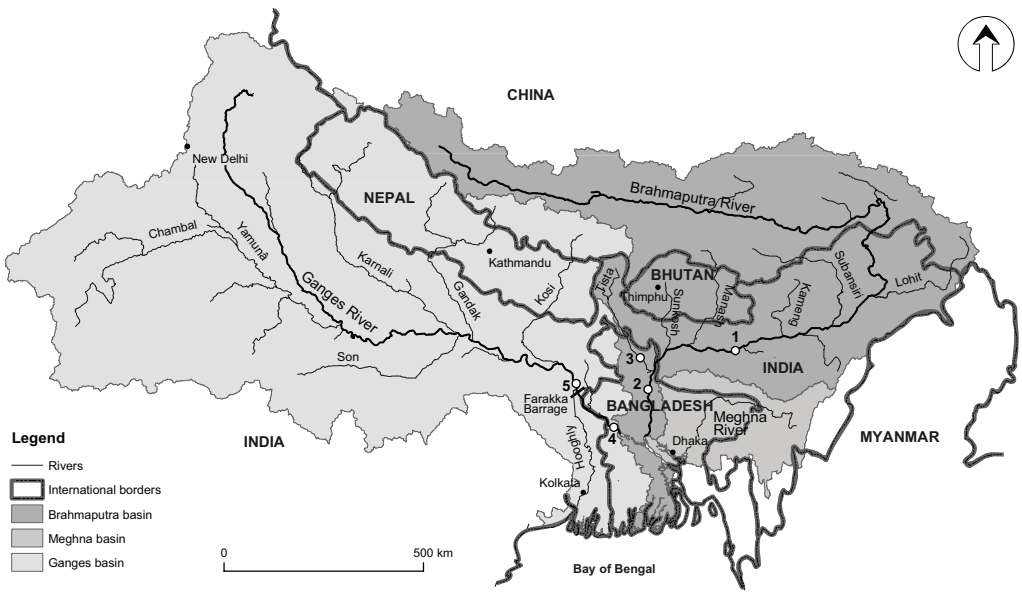


Figure 1 The Ganges, Brahmaputra and Meghna basins and locations of the measurement stations. 1: Pandu 2: Bahadurabad 3: Kaunia 4: Hardinge Bridge 5: Farakka.

Human Environment (1972), Rio Declaration on Environment and Development (1992) and Convention on Biological Diversity (1992). These studies include methodologies used in Publications I to III.

Publications V and VII: Data have been collected from both primary and secondary sources. Primary data and information have been collected from relevant organisations and experts during altogether six-month research trips to the study area (Nepal, Bangladesh and Bhutan) by the author in 2004, 2005 and 2007. Discharge data for the Ganges and Brahmaputra rivers were obtained from the *Bangladesh Water Development Board* and the *Global Runoff Data Centre*, Germany (see Figure 1). The study includes analysis of the water related bilateral agreements between the riparian countries. Secondary data have been collected from various international, governmental and local organizations as well as published journal articles, books, documents and reports.

3 RESULTS AND DISCUSSION: IWRM AT POLICY LEVEL

The first part of this section briefly summarises the evolution of the IWRM concept and its key principles (subsection 3.1). This is followed by the summary of key results and discussion of Publications I to IV (subsections 3.2-3.5) that focus on the constraints and opportunities of implementing the IWRM concept at policy level.

3.1 IWRM: EVOLUTION AND KEY PRINCIPLES

IWRM is not a new idea. In a number of countries, water management has been institutionalised in an advanced and integrated manner over centuries. Embid (2003) writes that Spain was probably the first country to organize water management on the basis of river basins, as it adopted the system of confederaciones hidrográficas in 1926. Over the last several decades, there have been serious attempts to implement IWRM in different global regions. In the 1940s, an early version of IWRM occurred when the Tennessee Valley Authority began to develop the water resources for that region (Barkin & King, 1986; Tortajada, 2004). A later example occurred in 1960 in Hessen, Germany, where Integrated Water Resources Management Planning was prepared on the basis of a multidisciplinary integrated approach (Berg, 1960; cited in Kaitera, 1963). Another example is Finland, which produced integrated basin-wide development plans, institutionalised the process by establishing the National Board of Waters, and implemented those plans (NBWF, 1974; Vakkilainen 2003).

At the United Nations Conference on Water (Mar del Plata, 1977), IWRM was the recommended approach to incorporating the multiple competing uses of water resources. After that, several international events have been held with a focus on water issues. Among them, the most influential events such as the International Conference on Water and Environment (Dublin, 1992), UN Conference on Environment and Development (Rio de Janeiro, 1992), Second World Water Forum (The Hague, 2000), International Conference on Freshwater (Bonn 2001), World Summit on Sustainable Development (Johannesburg, 2002), Third World Water Forum (Kyoto, 2003) and Fourth World Water Forum (Mexico, 2006) collectively led to breakthroughs that thrust the IWRM concept onto the international water and development agenda.

Publications I and II critically analyse the outcomes of the Mar del Plata, Dublin, The Hague, Bonn and Johannesburg events. Publication III analyses the outcomes of the Rio De Janeiro, Kyoto and Mexico Events. Below the key outcomes of six major international water events are briefly summarised.

3.1.1 Dublin 1992: International Conference on Water and Environment

In January 1992, the International Conference on Water and Environment Issues for the 21st Century, was held in Dublin, Ireland. Current thinking on the crucial issues in water resources is heavily influenced by the Dublin Principles, which are (ICWE, 1992):

1. Fresh water is a finite, vulnerable and essential resource, which should be managed in an integrated manner.

2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

3. Women play a central role in the provision, management and safeguarding of water.

4. Water has an economic value and should be recognized as an economic good, taking into account affordability and equity criteria.

3.1.2 Rio de Janeiro 1992: UN Conference on Environment and Development

The UN Conference on Environment and Development (UNCED), also known as The Earth Summit, was held in Rio de Janeiro, 3-14 June 1992. This Summit, attended by 108 Heads of State or Government of the world, was the most influential of its kind. The key declaration adopted in Rio was Agenda 21, which was endorsed by 178 States.

Chapter 18 of Agenda 21 exclusively dealt with freshwater issues (UNCED, 1992). Seven programme areas are proposed for the freshwater sector:

1. Integrated water resources development and management

2. Water resources assessment

3. Protection of water quality and aquatic ecosystems

4. Drinking water supply and sanitation

5. Water and sustainable urban development

6. Water for sustainable food production and rural development

7. Impacts of climate change on water resources

3.1.3 The Hague 2000: Second World Water Forum & Ministerial Conference

World Water Forums, organised by the World Water Council and held every three years since 1997, are the largest international events in the field of water. The key aim of this series of global water events is to enable multi-stakeholder participation and dialogue to influence water policy making at the global level, thus assuring better living standards for people all over the world and a more responsible social behaviour towards water issues in-line with the pursuit of sustainable development (FWWF, 2006).

On 17-22 March 2000, the Second World Water Forum was held in The Hague, Netherlands. The key issues raised in the Forum related to IWRM are (WWC, 2000):

1. Privatisation: To achieve water security, water must be everybody's business but, on the other hand, the government monopoly on water management should not be replaced by a private monopoly.

2. Changing the full cost for water services: Users should in fact be charged the full cost of the services – with appropriate subsidies made available to the poor.

3. Right to access: Water is not only considered essential for human health, it is also desperately needed by millions of poor women and men in rural areas for productive reasons: to grow the family food or generate income. Right of land and use of water are key determinates for people's potential to break the poverty trap.

4. Participation: Water can empower people and women in particular, through a participatory process of water management. Participation implies sharing of power, democratic participation of citizens in elaborating or implementing water policies and projects, and in managing water resources.

3.1.4 Bonn 2001: International Conference on Freshwater

In December 2001, the International Conference on Freshwater took place in Bonn, focusing on water as a key to sustainable development. The Bonn Conference was the major preparatory event in the water field towards the Johannesburg Summit of 2002. The conference reviewed the role of water in sustainable development, took stock of progress in the implementation of Agenda 21 and identified how its implementation can be improved. It is built on many previous efforts and conferences, which have defined the challenges, development principles and policies related to water and sustainable development. There is often a gap between making such policies and putting them into practice. So the conference focused on practical ideas. The Bonn Keys are listed below (ICFW, 2001):

1. The first key is to meet the water security needs of the poor.

2. Decentralization is the key. The local level is where national policy meets community needs.

3. The key to better water outreach is new partnerships.

4. The key to long-term harmony with nature and neighbour is cooperative arrangements at the water basin level, including across waters that touch many shores. For this reason IWRM is needed to bring all water users to the information sharing and decision making tables.

5. The essential keys are stronger, better performing governance arrangements.

3.1.5 Johannesburg 2002: The World Summit on Sustainable Development

At the end of August and beginning of September 2002, The World Summit on Sustainable Development (WSSD) was held in Johannesburg, South Africa. The main points focusing on WSSD Plan of Implementation relating to IWRM are listed below (WSSD, 2002):

1. Developing IWRM and water efficiency plans by 2005 for all major river basins of the world.

2. Developing and implementing national/ regional strategies, plans and programmes with regard to IWRM.

3. Improving the efficiency of water uses.

4. Facilitating the establishment of public-private partnership.

5. Developing gender sensitive policies and programmes

6. Involving all concerned stakeholders in all kinds of decision-making, management and implementation processes.

3.1.6 The Third World Water Forum - Kyoto 2003

The forum was held in March 2003 in Kyoto, Japan. The forum suggested IWRM as the way to achieve sustainability regarding water resources. The ministerial declaration addressed the necessity of sharing benefits equitably, engaging with pro-poor and gender perspectives in water policies, facilitating stakeholder participation, ensuring good water governance and transparency, building human and institutional capacity, developing new mechanisms of public-private partnership, promoting river basin management initiatives, cooperating between riparian countries on transboundary water issues, and encouraging scientific research. The ministerial declaration also vowed support to enable developing countries to achieve the UN Millennium Development Goals, and for developing IWRM and water efficiency plans in all river basins worldwide by 2005, the target set at the World Summit on Sustainable Development (TWWF, 2003a; 2003b).

3.2 IWRM PRINCIPLES AND PRACTICE: A CASE STUDY ON EU WFD

To examine the gap between IWRM principles and practice, as a case study, Publication II takes one of the most influential and contemporary water policy tools into consideration, namely, the EU Water Framework Directive (EU WFD). The outcome of four major international water events concerning IWRM, namely, the International Conference on Water and Environment (Dublin, 1992), the Second World Water Forum (The Hague, 2000), the International Conference on Freshwater (Bonn, 2001) and the World Summit on Sustainable Development (2002) are compared with the EU WFD. The aim is to analyse how the EU WFD complies with the principles concerning IWRM agreed in major international water events and to focus on the mismatches between them. When the principles of IWRM and the EU WFD are compared, seven notable mismatches are found (Figure 2), even though several EU countries played a leading role in those international water events and EU countries also follow the outcome of these conferences when they donate aid for development in developing countries.

Consequently the question arises whether the outcomes of different international conferences regarding IWRM are not effective and efficient enough to sufficiently influence EU policies for better water management or whether developing and developed countries are required to use a different set of IWRM principles? Finally, why does the EU adopt different principles in its own water policies from those it promotes in global forums – should it follow the former or the latter ones when aiding developing countries? Although international organisations and the world scientific community offered commonly agreed theoretical principles of IWRM to be applicable worldwide, in practice, these principles are often overlooked by the international community. Often there is a huge gap between principles and practice.

3.3 IWRM PRINCIPLES AND PRACTICE: A CASE STUDY ON MEXICO WORLD WATER FORUM'S MINISTERIAL DECLARATION

On 16-22 March 2006, the Fourth World Water Forum was held in Mexico City. Around 20,000 people from around the world participated in 206 working sessions. The Forum was attended by official representatives and delegates from 140 countries, including 120 mayors, 78 ministers, 150 legislators, 1395 journalists, experts, NGOs, companies, and civil society representatives (WWC, 2006). On 22 March 2006, The Ministerial Conference adopted the Mexico Forum's Ministerial Declaration (hereinafter Mexico Declaration).

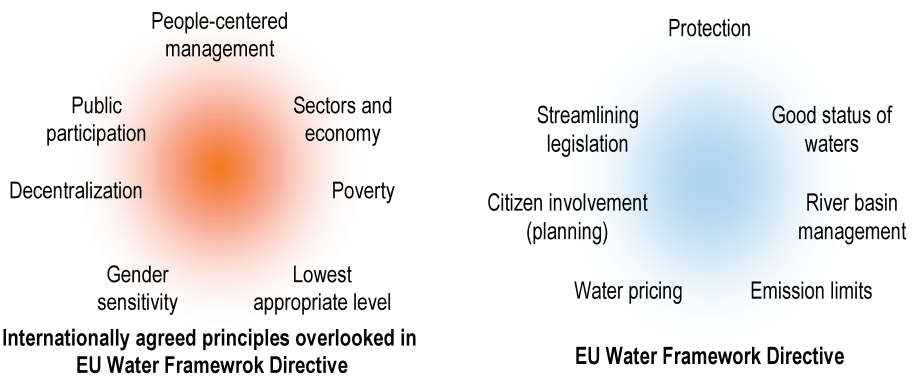


Figure 2 The internationally agreed water management principles and the EU Water Framework Directive focus on different issues. Does the EU require others – mainly developing and transition countries – to follow a different set of principles than it requires from its member countries?

It is worthwhile to mention that the World Water Forums are not organised under the United Nations and therefore their declarations are not binding in nature but rather bona fide recommendations. However, Ministerial Declarations of the World Water Forums decidedly influence the global water policies and water resources management practices.

Since these declarations have global significance and contribute noticeably to shaping national and international water policies worldwide, Publication III analyses the scope of the Mexico Declaration (2006) in comparison with globally accepted water management principles.

In Publication III, it is revealed that the Mexico Declaration does not incorporate the following ten globally accepted water management principles:

1. There are no policy guidelines and recommendations for ecosystem conservation.

2. There are no policy guidelines for achieving food security and rural development through agricultural water management.

3. The impacts of global climate change on water resources are not included.

4. The role of inland fisheries and aquaculture towards effective water resources management are not included.

5. Mexico Declaration does not recognise the necessity of transboundary river basin management.

6. There is no clear guideline for the active participation of all stakeholders in the management of water resources.

7. Mexico Declaration does not recognise the interconnection between water and sustainable forest management.

8. The need for data and information sharing, technology transfer, and research and development are not included.

9. There is no instruction for incorporating the environmental and social consideration in hydropower development projects.

10. There is no guideline for implementing integrated water resources management.

The challenges of development and management of water resources are closely linked at local, national, regional and global levels. The future of the world water security will be decisively affected by the ways in which countries manage their water resources. Primarily because of the importance of the Fourth Mexico World Water Forum's Ministerial Declaration in shaping the national and regional water policies worldwide, the exclusion of major water management principles discussed above would produce fragmented and unsustainable water resources management.

3.4 FUTURE CHALLENGES OF IWRM

The international community now recognises IWRM as the most efficient and effective water resources management mechanism to enhance economic well-being, social equity, and environmental sustainability. In practice, though, implementation of the IWRM concept is challenging. The two case studies presented in Publication II and III (sections 3.2 and 3.3) reveal that existing policies tend to take a rather narrow view of the concept and have largely failed to incorporate the principles.

Future challenges remain in reducing the gap between theoretically agreed principles and implementation. The integration of different sectors related to water management is a difficult and challenging task. Moreover, the problems and solutions associated with IWRM implementation in different regions are not universal. Overly general or universal policies and guidelines for implementing IWRM may become counterproductive.

Publication I identifies seven points and approaches that need to be addressed by water professionals far more carefully than in the contemporary guidelines to successfully implement IWRM. These are summarised as follows:

1. *Privatisation*: Privatisation of the water sector needs to be approached with caution, and far more attention must be given to the issue's many facets than is done in today's ideological debate.

2. *Water as an economic good*: The application of economic principles to the allocation of water is acceptable and provides a simple tool for the development of water services in a more efficient direction. However, water should not be treated as a market-oriented commodity when it comes to domestic use for very basic needs (Gunatilake & Gopalakrishnan, 2002; Rahaman and Varis, 2005), particularly for people in extreme poverty. More discussion, analysis, study, and commitment are needed in deciding whether water is a common or an economic good.

3. *Transboundary river basin management*: The necessity of river basin management received positive attention at The Hague Forum, the Bonn Conference, and the WSSD summit; however, no clear mechanism for implementing the river basin management concept into practice has been suggested. An increasing number of countries are experiencing water stress; nevertheless, in most river basins, mechanisms and institutions to manage water resource disputes are either absent or unsatisfactory (UNESCO & Green Cross International, 2003). Not only should plans and goals be developed, but so should practical frameworks for implementing joint river basin management through efficient institutions and productive participation of all riparian states. In addition, a greater focus on legal institutional arrangements is necessary, as it is practically absurd to implement integrated policy without some legal bindings. A common policy, including a supporting legal framework, is vital for implementing integrated transboundary river basin management.

4. *Restoration and Ecology*: IWRM principles do not clearly focus on or address the mechanism of river restoration, which is necessary for sustainable water resources management in areas that have undergone or are presently subjected to notable modifications.

5. *Fisheries and Aquaculture*: Fisheries and aquaculture are crucial for human survival and poverty reduction; they provide an inexpensive source of protein to meet nutritional demands in many parts of the world, and therefore should command special attention within IWRM.

6. *Need to Focus on Past IWRM Experience*: During the 1970s, many European countries implemented a considerable number of comprehensive watershed plans that resemble today's IWRM plans. One example is Finland, which produced basin-wide plans,[1] institutionalised the process by establishing the National Board of Waters, and implemented those plans (NBWF, 1974; Vakkilainen, 2003). One of many implementations was the countrywide construction of municipal wastewater treatment plants, which at that time were already more advanced than current plants in many countries that promote IWRM worldwide. Unfortunately, the current IWRM mechanism does not focus on this kind of highly balanced experience in integrated plans, which would facilitate more concrete IWRM development.

[1] See, e.g., the plan for the Lower Kymi River (NBWF 1974), which served as a guiding framework for water district authorities in Finland (Vakkilainen, 2003).

7. *Spiritual and Cultural Aspects of Water*: Water is one of our compelling links with the sacred, with nature, and with our cultural heritage (Dooge, 2003). Regrettably, the current IWRM mechanism does not properly acknowledge water's spiritual and cultural dimensions.

The success of IWRM mostly depends on its implementation competence. The main challenge is the practical implementation of the theoretically agreed-upon IWRM principles (Lahtela, 2001; Biswas, 2005). Publication I has identified only some of the shortcomings in meeting IWRM challenges. These are not comprehensive since, as mentioned before, conditions vary enormously, but these issues are important in many localities, even though neglected in the concurrent IWRM discourse.

3.5 TRANSBOUNDARY WATER RESOURCES MANAGEMENT PRINCIPLES

Publication IV identifies the transboundary water resources management principles that are associated with the integrated management of

Table 1 Transboundary water management principles and relevant articles of international conventions, agreements/treaties.

Principles	Relevant Articles		
	Helsinki Rules (1966)	UN Watercourses Convention (1997)	International Treaties
Reasonable and equitable utilization	Articles IV, V, VII, X, XXIX (4)	Articles 5, 6, 7, 15, 16, 17, 19	1995 SADC Protocol on Shared Watercourse Systems (Article 2), 2002 Sava River Basin Agreement (Articles 7-9), 1995 Mekong Agreement (Articles 4-6, 26), 1992 UNECE Water Convention (Articles 2.2c)
Not to cause significant harm	Articles V, X, XI, XXIX (2)	Articles 7, 10, 12, 15, 16, 17, 19, 20, 21(2), 22, 26(2), 27, 28(1), 28(3)	1995 SADC Protocol on Shared Watercourse Systems (Article 2), 2002 Sava River Basin Agreement (Articles 2, 9), 1995 Mekong Agreement (Articles 3, 7, 8), 1992 UNECE Water Convention (Articles 2.1, 2.3, 2.4, 3)
Cooperation and information exchange	Articles XXIX (1), XXIX (2), XXXI	Articles 5(2), 8, 9, 11, 12, 24(1), 25(1), 27, 28(3), 30	1960 Indus Waters Treaty (Articles VI-VIII), 1995 SADC Protocol on Shared Watercourse Systems (Articles 2- 5), 2002 Sava River Basin Agreement (Articles 3-4, Articles 14-21), 1995 Mekong Agreement (Preamble, Articles 1, 2, 6, 9, 11, 15, 18, 24, 30), 1992 UNECE Water Convention (Articles 6, 9, 11, 12, 13, 15, 16)
Notification, consultation and negotiation	Articles XXIX (2), XXIX (3), XXIX (4), XXX, XXXI	Articles 3(5), 6(2), 11-19, 24(1), 26(2), 28, 30	1960 Indus Waters Treaty (Articles VII [2], VIII), 1995 SADC Protocol on Shared Watercourse Systems (Articles 2[9], 2[10]), 2002 Sava River Basin Agreement (Part Three and Four, Article 22), 1995 Mekong Agreement (Articles 5, 10, 11, 24), 1992 UNECE Water Convention (Article 10)
Peaceful settlement of disputes	Articles XXVI-XXXVII	Article 33	1960 Indus Waters Treaty (Article IX, Annexure F, G), 1995 SADC Protocol on Shared Watercourse Systems (Article 7), 2002 Sava River Basin Agreement (Articles 1, 22-24, Annex II), 1995 Mekong Agreement (Articles 18.C, 24.F, 34, 35), 1992 UNECE Water Convention (Article 22, Annex IV)

shared watercourses. The study reveals that the principle of equitable and reasonable utilization, obligation not to cause significant harm, principles of cooperation, information exchange, notification, consultation and peaceful settlement of disputes are widely acknowledged by modern international conventions, agreements and treaties (Table 1). These principles form the basis of the *1966 Helsinki Rules on the Uses of the Waters of International Rivers* and the *1997 UN Convention on Non-Navigational Uses of International Watercourses*. These principles could serve as guiding principles and provide a framework for further dialogue among the riparian countries for creating effective transboundary water resources management of shared watercourses. Table 1 summarises the key results of Publication IV.

4 RESULTS AND DISCUSSION: IWRM AT FIELD LEVEL

Water policies provide guiding principles and framework for IWRM, but the implementation of these principles and framework requires understanding of the complex and multidimensional nature of water resources development and management at field level. As mentioned in the Introduction (subsection 1.1), this understanding is even more important in international river basins in order to expand the knowledge base regarding the constraints and opportunities of implementing IWRM. This section summarises the key results and discussion of Publications V to VII (subsections 4.1-4.3) that deal with the constraints and opportunities of implementing the IWRM concept at field level with two case studies from Ganges and Brahmaputra river basins located in South Asia.

4.1 INTEGRATED WATER RESOURCES MANAGEMENT OF THE GANGES RIVER BASIN: CONSTRAINTS AND OPPORTUNITIES

Publication V examines the sources of water conflicts and previous cooperation between the riparian countries in the Ganges basin. It identifies the issues related to the utilization of the Ganges water resources, regional water-based development potentials and views of riparian countries on integrated Ganges basin management. It then identifies potential benefits from integrated Ganges basin management and recommends guidelines to overcome the constraints on integrated Ganges management. This section gives a brief overview of the Ganges river basin based on Publication V and the key findings of Publication V.

4.1.1 Ganges Basin Water Resources

The Ganges basin is located 70–88°30' east longitude and 21–31° north latitude. The river Ganga rises in the Gangotri glacier in India. Many important tributaries including Mahakali, Gandak, Kosi, and Karnali originate in Nepal and China (Tibet). The Ganges river has a total length of about 2600 km and the total drainage area is about 1080000 square kilometres shared by China, Nepal, India and Bangladesh (Table 2, Figure 1). The river finally empties into the Bay of Bengal. The rivers of Nepal contribute more than 45% of the total flow of the Ganges and nearly 70% of its dry-season (January to May) flow reaching Farakka (for details see Publication V).

The temporal and spatial distribution of water resources is one of the main challenges for sustainable water management in the Ganges basin and, hence, for attaining food security and achieving socio-economic development. During the monsoon months (June–October), there is abundant water but during non-monsoon months (January–May) the countries become water stressed (Biswas & Uitto, 2001). At Farakka, the Ganges has an average annual flow (1949–1973) rate of 12,105 m^3 s^{-1}. During June–October, the average flow is 24,526 m^3 s^{-1}, whereas during January–May the average flow is only 2,199 m^3 s^{-1} (GRDC, 2006).

The current legacy of mistrust, perceptional differences, lack of cooperation and vision among the riparian countries of the basin make the integrated development and utilisation approach to the Ganges basin's huge water resources a difficult task (Ahmad et al., 2001; Onta, 2005). An important factor in the context of managing Ganges water is

Table 2 Ganges basin area distribution and water resources (n/a means not available). Sources: Rangachari & Verghese, 2001: 82; Pun, 2004: 11; Onta, 2005: 149; IIDS, 2000.

Country	Drainage area (1,000 km^2)	Arable land (1,000 km^2)	Population (2001) (million)	Surface water availability (10^9 m^3)	Ground water availability (10^9 m^3)
India	861	602	440	525	171
Bangladesh	46	30	37	197	22[2]
Nepal	140	26	23	208	12
China (Tibet)	33	Negligible	1	n/a	n/a
Total	1080	658	501	930	205

the fact that Nepal controls the headwaters of the Ganges and regional development of the Ganges is being limited to bilateral talks and arrangements.

4.1.2 Conflicts over Water

This detailed conflict analysis reveals that the conflict over the Ganges water between Bangladesh (the then Pakistan) and India[3] dates back to 1951 when India decided to construct the Farakka barrage in order to divert water from the Ganges to the Hooghly river by a 42-kilometer long feeder canal with a carrying capacity of 1133 m^3/sec (Abbas, 1984; Figure 1). The 2246-meter long Farakka barrage (completed in 1974), located 17 km upstream of Bangladesh near Monohorpur, was built without consultation with Bangladesh and began operation on 21 of April 1975 (Samarkoon, 2004). It stands close to the point where the main flow of the river enters Bangladesh, and the river Hooghly (a distributary of the Ganges) continues in West Bengal past Kolkata. Since the commissioning of the barrage, the Ganges flow in Bangladesh measured at Hardinge bridge point decreased substantially during dry season (January-May) (Figure 3), which causes socio-economical and environmental problems for Bangladesh (Mirza, 2004; Samarakoon, 2004; Crow et al., 1995). Until today, Farakka barrage is the key source of water conflict between the two riparians due to the reduced dry season flow in Bangladesh. Table 3 presents the chronology of water conflicts and cooperation between the two nations.

Sarada (1920), Kosi (1954) and Gandak (1959) barrage agreements between India and Nepal are the key sources of water conflicts and mistrust between the two upstream riparians of the basin (for details see Publication V). This acute mistrust even led Nepal to incorporate Article 126 (2) in its constitution in 1990, which requires that any "treaty" pertaining to natural resources and certain other matters be ratified by a two-thirds majority vote of the country's parliament (Onta, 2001:110; Marty, 2001:207).

4.1.3 Water Cooperation along the Ganges Basin

The history of water cooperation along the Ganges basin dates back to 29 April 1875 when an agreement was signed between the British Government and the State of Jind for regulating the supply of water for irrigation from the western Jumna canal (amended on 24 July 1892). On 29 August 1893, the Agreement between the British Government and the Patiala State regarding the Sirsa branch of the Western Jumna Canal was signed (IWLP, 2008; Beach et al., 2000:168).

[2] This figure includes ground water availability for the whole of Bangladesh

[3] India and Pakistan gained independence in 1947. From 1947 to 1970, Bangladesh was part of Pakistan that was known as East Pakistan. In 1971, Bangladesh gained independence from Pakistan.

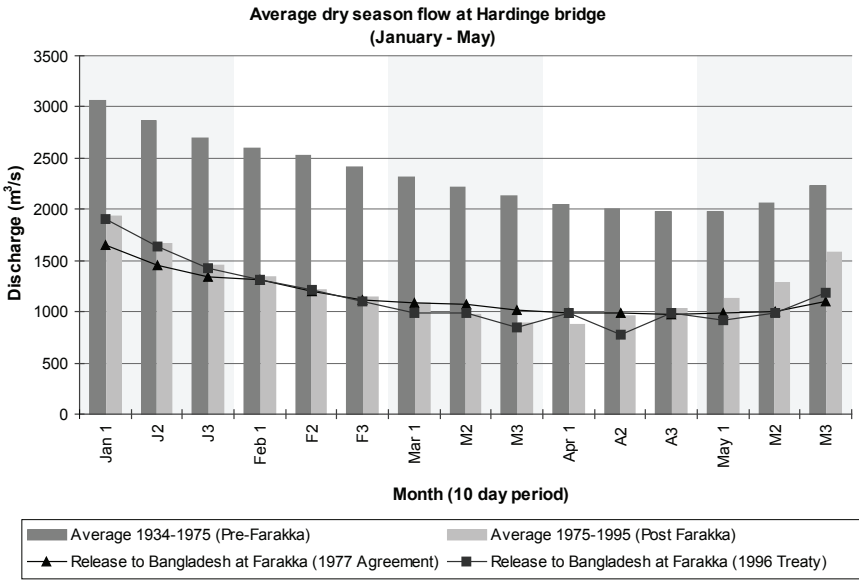


Figure 3 Average 10-day discharge (dry season flow, January–May, 1934–1995) of the Ganges measured at Hardinge Bridge and water allocation in the 1977 Agreement[5] and the 1996 Treaty.[6]

After that, six bilateral agreements/treaties and three Memorandums of Understanding (MoU)[4] have been signed between the riparian countries. The agreements/treaties are as follows:

1. 1920 Agreement between His Majesty's Government of Nepal and India (the then British Empire) for constructing Sarada barrage on the Mahakali river.

2. Agreement between His Majesty's Government of Nepal and the Government of India concerning the Kosi Project, 25 April 1954. The treaty was subsequently amended on 19 December 1966.

3. Agreement between His Majesty's Government of Nepal and the Government of India on the Gandak Irrigation and Power Project, signed in Kathmandu 4 December 1959. The treaty was subsequently amended on 30 April 1964.

4. Agreement between the Government of the People's Republic of Bangladesh and the Government of the Republic of India on sharing of the Ganges waters at Farakka and on augmenting its flows, signed on 5 November 1977 in Dhaka.

5. Treaty between Nepal and India concerning the integrated development of the Mahakali river including Sarada barrage, Tanakpur barrage and Pancheshwar Project, 12 February 1996, signed in New Delhi.

6. Treaty between the Government of the People's Republic of Bangladesh and the Government of the Republic of India on sharing of the Ganga/Ganges waters at Farakka, signed on 12 December 1996 in New Delhi.

[4] Agreement concluded at the administrative level is known as Memorandum of Understanding (Birnie & Boyle, 2002:13).

[5] According to Article II (ii) of the 1977 Ganges Water Agreement, in case the Ganges flow at Farakka reduces substantially, Bangladesh will get 80% of the water allocated in the Agreement. This is widely known as the *Guarantee Clause*.

[6] Subject to the conditions of the 1996 Ganges Water Treaty: a) India and Bangladesh each shall receive a guaranteed 991 $m^3 s^{-1}$ of water in alternate three 10-day periods during the period from 11 March to 10 May (Article II and Annexure I); b) if actual availability corresponds to the average flows of the period 1949–1988 (Annexure II); c) if the flow at Farakka is above 1,415 $m^3 s^{-1}$ (Article II).

Table 3 Chronology of water conflicts and cooperation between India and Bangladesh.

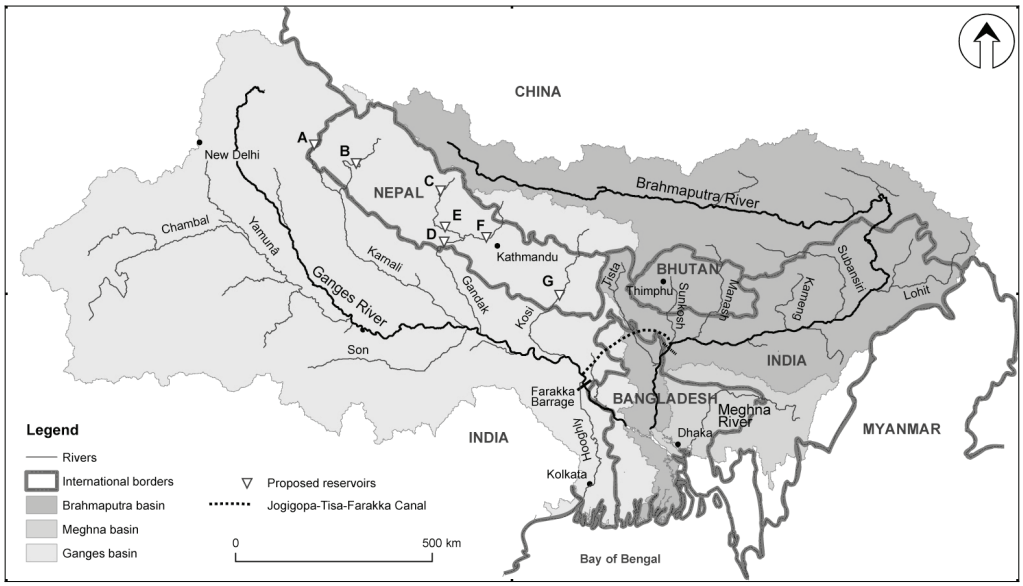
Time Line	Outcome
1951	Pakistan (Bangladesh after 1971) officially objected to India's plan to construct Farakka barrage on 29 October 1951.
1961	India officially admitted the unilateral construction of the barrage on 30 January 1961.
1972	On 24 November 1972, India and Bangladesh signed statutes of the Indo-Bangladesh Joint River Commission (JRC).
1974	Farakka barrage construction is completed.
1975	On 18 April 1975, Bangladesh allowed India to divert 310-450 m^3/sec of Ganges water from 21 April to 31 May 1975 to test the feeder canal of the Farakka barrage through a ministerial level declaration. Farakka barrage started operation on 21 of April 1975.
1976	India continued unilateral diversion of the Ganges flow beyond the stipulated period in the 1975 ministerial declaration throughout the 1976 dry season and withdrew 1133 m^3/sec of water (full capacity of the feeder canal) at Farakka. Bangladesh raised the issue at the United Nations. On 26 November 1976, the UN General Assembly adopted a consensus statement, which directed both countries to urgently negotiate a fair and expeditious settlement of the Farakka problem to promote the well being of the region (UN, 1976).
1977	Upon the direction of the United Nations, India and Bangladesh signed the 1977 Ganges Water Agreement for the duration of 5 years.
1978	According to the instructions of the 1977 Agreement (Articles VIII-XI), Bangladesh and India exchanged their official proposals for augmenting the dry season flow of the Ganges. The Bangladesh side proposed augmentation of dry season flow through building storage reservoirs in Nepal. India proposed augmentation through diversion of water from the Brahmaputra river to the Ganges river. Neither side agreed to the other's proposal.
1982	A MoU was signed between the two countries for sharing dry season flow of Ganges at Farakka in 1983 and 1984.
1985	There was no agreement for the 1985 dry season (January to May). In November, a MoU was signed for three years (1986-1988), which expired on 31 May 1988.
1986	On 29-31 October 1986, a team of experts from Bangladesh and India officially approached Nepal regarding the potential water storage projects at upstream of the Ganges basin in Nepal. The meeting ended without any outcome.
1988	1985 MoUs expired. No agreement for the period 1988-1996.
1993	Bangladesh raised the issue at the Commonwealth Summit held in Cyprus in October 1993.
1995	On 23 October 1995, Bangladesh again raised concern in the 50th UN General Assembly about the negative consequences on Bangladesh due to the unilateral water diversion at Farakka barrage.
1996	An agreement on sharing the Ganges water at Farakka was signed for the duration of 30 years.
2005	In the 36th Indo-Bangladesh JRC meeting, held on September 2005, Bangladesh again proposed to have tripartite talks involving Nepal for building water reservoirs in Nepal in order to augment the dry season flow of the Ganges.

4.1.4 Views of Riparian Countries on Integrated Ganges Basin Management

Analyses of the viewpoints of the three riparian countries on the Ganges basin development reveals that Nepal wants to exploit the basin's huge hydropower potential, whereas Bangladesh wants the water managed in such a way as to minimize flooding during monsoon months and water shortage during dry months. India, on the other hand, wants to divert water from the north eastern Brahmaputra basin for augmenting dry season flow of the Ganges basin and for reducing flood during monsoon (Figures 4 and 5; Publication V).

Bangladesh claims that the augmentation of the Ganges water should be solved within the Ganges basin through constructing storage reservoirs in upstream Nepal and that there is enough water. On the other hand, India's proposal claims that diverting water from the Brahmaputra to the Ganges is the best solution for flow augmentation during the dry season. Put simply, Bangladesh always wants to share water over time multilaterally by involving Nepal; India wants to share water over space bilaterally with Bangladesh. In short, there is an unresolved dilemma between the proposals of Bangladesh and India, whether to share water over time or space. Due to the problems that Farakka barrage in the Ganges river has caused, Bangladesh is worried that India has a similar plan to siphon off water from the Brahmaputra river (Novak, 1993:214) as well as the Meghna river through the proposed River Interlinking Project or New Indian Line (see Figure 5).

Nepal wants to attain maximum benefits from the multilateral and/or bilateral water development projects. The hydropower potential of Nepal is 83000 MW, of which 42000 MW is economically feasible. The identified 22 large storage reservoirs



India's Proposal: Brahmaputra- Ganges Link Canal

Bangladesh's proposal: Reservoirs in Nepal

A-Pancheswar **B**-Chisapani **C**-Kaligandaki (1) **D**-Kaligandaki (2)
E-Seti **F**-Trisulganga **G**-Sapt Kosi

Figure 4 Riparian views on integrated Ganges basin development.

in Nepal would have a live storage capacity of around 82 x 109 m^3. Nepal advocates the sharing of benefits from water use - whether from hydropower, agriculture, flood control, flow regulation, and the preservations of healthy aquatic ecosystems - not the benefits from water itself. The mistrust caused by the Sarada, Kosi and Gandak agreements and subsequent developments has led Nepal to be very cautious and suspicious regarding water issues (Onta, 2001; Marty, 2001; for details see Publication V). Most often, other riparians fail to understand that controlling Nepal headwater without consulting, compensating, and offering reasonable benefits to Nepal from the proposed projects is not practically possible.

4.1.5 Key Findings and Recommendations

The control of water is the control of livelihood. The control of the Ganges river has become a source of tension and dispute and an issue of sovereignty and strategic necessity in the region. Past bilateral efforts have not been conducive to the balanced development of the resources, and have been a source of antagonism between the riparian countries. The findings suggest that integrated Ganges basin management based on regional cooperation between Nepal, India and Bangladesh holds opportunities for mutual benefits. The four types of benefits – to the river, from the river, reducing the costs because of the river and beyond the river – could offer environmental, social, economic and political benefits for the riparian countries. The integrated management approach has the potential to reverse the conflict into cooperation and promote sustainable development throughout the Ganges basin.

Publication V recommends that the following issues are worth serious consideration in order to overcome the current impediments to the achievement of integrated Ganges development:

1. The conflict analysis shows that Bangladesh and India are the key players in the Ganges basin. Nepal's official concerns had not been effectively taken into account while preparing Bangladesh's 1978 proposal for

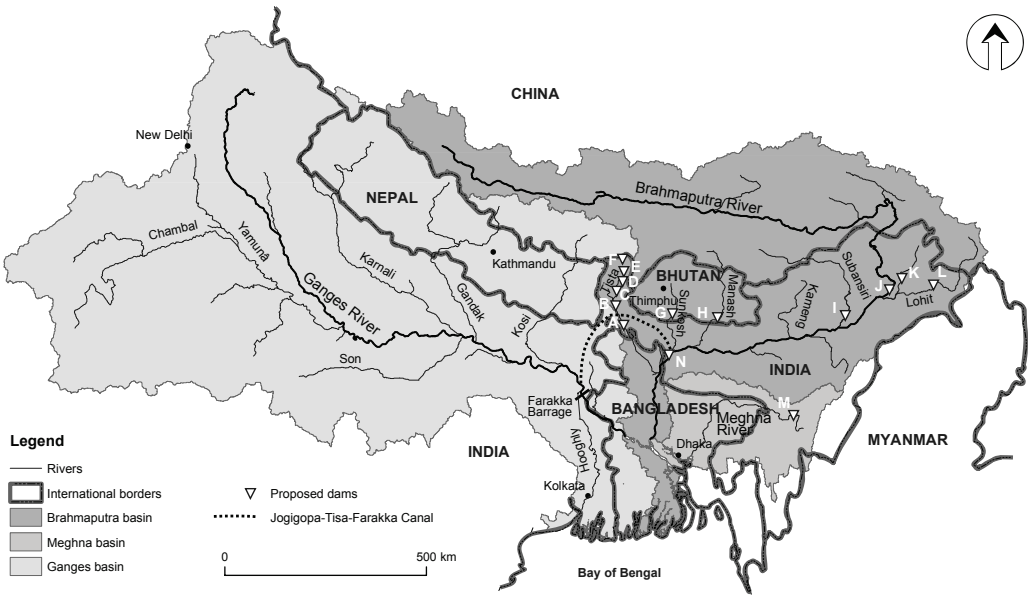


Figure 5 The New Indian line (Brahmaputra-Ganges Link Canal) and some proposed dams in the Brahmaputra. A. Tista Low Dam III, B. Tista Low Dam IV C. Rangit D. Tista IV E. Lachen F. Tista V G. Sonkosh H. Manas I. Subansiri J. Dihang K. Dibang L. Lohit M. Tipaimukh N. Jogigopa barrage.

water storage reservoirs in Nepal. On the other hand, India's proposal for constructing major dams in the Brahmaputra basin had not included consultation with China and/or incorporated China's views and future plans for development of the basin. Both plans have major weaknesses as both overlooked the burning necessity of consulting with the upstream countries, Nepal in the Ganges and China in the Brahmaputra. Controlling Nepal's water without consulting with Nepal is certainly not feasible. It is also imperative to bring China into regional consultation to ensure that future development plans by China would not undermine the Brahmaputra basin development efforts proposed by India.

2. The Farakka controversy tends to overshadow the main problem of Ganges basin water management. Addressing temporal and spatial distribution of water, which is the key challenge to the region, must be at the forefront. Insufficient water availability in the non-monsoon period is the key reason for the conflict. Water storage in the monsoon period to augment the dry season flow could ensure water availability round the year. Nepal's huge hydropower and water storage potential should be utilized by multilateral cooperation. In addition, the water storage and hydropower potential of the Brahmaputra basin should be utilized by the riparian countries with a broader and open-minded collaboration with China, which controls the headwaters of the Brahmaputra.

3. Past bilateral approaches show that the absence of multilateral integrated management poses difficulties for efficient and effective Ganges basin water management. Lack of effective institutional mechanisms to implement the treaty causes water conflict and mistrust among the riparian countries. A multilateral management approach with a joint river basin institution is vital. Effective dispute resolution mechanisms should be mutually agreed before any multilateral arrangement is finalized.

4. Benefits and costs associated with joint river management should be evaluated properly. Submergence of land, displacement of people upstream and downstream benefits resulting from flood control, flow regulation and hydropower generation must be taken into account before the storage projects are built.

5. Sharing hydro-meteorological, physical, environmental and socio-economic data among riparian countries is very important for the integrated management of the Ganges basin water resources. Information sharing usually engenders good will and can provide confidence-building measures among riparians. Unfortunately, India and Bangladesh classify river flow data as secret and use the lack of mutually acceptable data as a tactic to promote their own national interests (Beach et al., 2000: 51; Abbas, 1984; Fairless, 2008:280; Ohja & Singh, 2005:2). Through the India–Bangladesh Joint River Commission, mutually agreed hydrological data should be made publicly available. Mechanisms for "open information flow" should be included in future treaties.

6. India, Bangladesh and Nepal all proposed to construct large dams for integrated Ganges basin management (see Figures 4 and 5). As the region and all proposed dam sites are located in earthquake sensitive areas (ASC, 2008; Rangachari & Verghese, 2001: 108), sufficient care should be taken in terms of earthquake resistant design, constant vigilance during maintenance and construction, and rehabilitation and resettlement of the displaced people.

Table 4 Transboundary water resources management principles and relevant articles 1996 Ganges and Mahakali Treaties.

Principles	Ganges Treaty (1996)	Mahakali Treaty (1996)
Reasonable and equitable utilization	Articles IX, X	Articles 3, 7, 8, 9
Not to cause significant harm	Articles IX, X	Articles 7, 8, 9
Cooperation and information exchange	Preamble, Articles IV-VII, VIII, IX	Preamble, Articles 6, 9, 10
Notification, consultation and negotiation	Article IV-VII	Articles 6, 9
Peaceful settlement of disputes	Preamble and Article VII	Articles 9, 11

4.2 TRANSBOUNDARY WATER MANAGEMENT PRINCIPLES AND GANGES TREATIES

Publication VI concentrates on analysing the content of the 1996 Mahakali Treaty between Nepal and India and the 1996 Ganges Treaty between India and Bangladesh to find out to what extent the principles of transboundary water resources management (see Publication IV and section 3.5) are addressed in existing treaties. These two latest treaties of the Ganges basin are selected for this study as both were signed during the negotiation process of the UN Watercourses Convention (1997) and valid for significantly longer period, 75 years and 30 years respectively.

The findings of Publication VI reveal that both treaties incorporated the principle of equitable and reasonable utilization, obligation not to cause significant harm, principles of cooperation, information exchange, notification, consultation and peaceful settlement of disputes (see Table 4).[7] The inclusion of these internationally accepted transboundary water resources management principles in two bilateral treaties, concluded by three riparian countries, Nepal, India and Bangladesh, offers plenty of common ground and a window of opportunity to foster integrated water resources development and management along the Ganges basin that is suggested by Publication V. These principles could serve as guiding principles for water based collaborative development endeavours and for promoting multilateral cooperation among the riparian countries in the region.

4.3 INTEGRATED WATER RESOURCES MANAGEMENT OF THE BRAHMAPUTRA BASIN

Publication V (see section 4.1) identifies that it is imperative to bring China into regional consultation to ensure that future Brahmaputra basin development plans by China would not undermine the Brahmaputra basin development efforts proposed by India in relation to the integrated management of the Ganges river basin. So, Publication VII analyses the ongoing and future water development plans of India and China as well as Bhutan for the Brahmaputra basin management in more detail. It identifies the constraints and benefits for cooperation and regional development through integrated management of the Brahmaputra basin. This section gives a brief overview of the Brahmaputra river basin based on Publication VII and the key findings of Publication VII.

4.3.1 Brahmaputra Basin Water Resources

The Brahmaputra river basin is located 82°-97° east longitude and 21°-31° north latitude. The Brahmaputra is known as Tsangpo or Yarlung

[7] However, the absence of arbitration mechanisms makes the 1996 Ganges Treaty a less effective legal instrument than the 1996 Mahakali Treaty. For critical analyses of the water sharing mechanisms of the 1996 Ganges Treaty, see Tanzeema & Faisal, 2001; Salman and Uprety, 2002:170-183; Rahaman, 2006.

Table 5 Brahmaputra basin area distribution (n/a means not available). Sources: Sarma, 2005: 73; NHPC, 2008; Tianchou, 2001:110; Rangachari & Verghese, 2001:82; CWC, 2008; DOT, 2007; NPB, 2008.

Country	Drainage area (10^3 km^2)	% of area of basin	% of total area of country	Arable land (km^2)	Population (million) (1999)	Hydropower potential (10^3 MW)	% of basin's total hydropower potential
China (Tibet)	293	51.1	3.1	n/a	2	110	53.4
Bhutan	38.4	6.7	100	2,956	0.635	30	14.6
India	195	34.0	5.10	55,000	31	66	32
Bangladesh	47	8.2	32.64	36,000	47	0	0
Total	573.4	100		93,956	80	206	100

Zangbo in China, Brahmaputra in India and Jamuna in Bangladesh. The Tsangpo originates at an altitude of 5,150 m about 250 km to the northeast, in the Kailash range in China (Bandayopadhyay, 1995: 417). Many important tributaries including Lhasa, Dibang, Lohit, Subansiri, Amochu, Wangchu, Sunkosh, Manash and Tista originate in China, India and Bhutan. The river has a total length of 2,880 kilometres and the total drainage area of the Brahmaputra is about 573,394 square kilometres shared by China, India, Bhutan and Bangladesh (Figure 1; Table 5). The river finally empties into the Bay of Bengal in Bangladesh.

At Pandu (Assam), the Brahmaputra has an average annual (1956-1979) flow rate of 18,099 m^3 s^{-1} and flow volume of 571 x 109 m^3 (GRDC, 2006). At Bahadurabad (Bangladesh), the Brahmaputra has an average annual (1956-1979) flow rate of 19,331 m^3 s^{-1} and flow volume of 610 x109 m^3 (BWDB, 2007) (Figures 1 and 6). At Bahadurabad, during January-April the average flow is 5,186 m^3 s^{-1}, whereas during June to October the average flow is 35,712.5 m^3 s^{-1}. Of the total annual flow 77% occurs during the monsoon season (June-October). At Bahadurabad (1956-2006), the highest recorded flow is 103,128 m^3 s^{-1} on 8 September 1998 and the lowest recorded flow is 2,702 m^3 s^{-1} on 1 April 2001 (BWDB, 2007). The enormous hydropower potential of Brahmaputra basin is still mostly untapped.

4.3.2 Views of Riparian Countries on Integrated Brahmaputra Basin Management

Analysis of the viewpoints of the three riparian countries reveals that Bangladesh insists that Ganges and Brahmaputra are two separate river basins and those should be managed independently without any inter-basin water transfer (Publication V). Accordingly, the augmentation of the Ganges water should be solved within the Ganges basin through storage reservoirs in Nepal and that there is enough water. On the other hand, India insists that diverting water from the Brahmaputra is the best solution for flow augmentation and resolving the water problem in both the Ganges and Brahmaputra basins. Bangladesh has objected to India's plan on the grounds that Bangladesh needs 5,100 m^3 s^{-1} of water alone for irrigation from the Brahmaputra during February to April. At Bahadurabad, Bangladesh, during February to April, the average flow (1956-2003) is 5,684 m^3 s^{-1}. Sharing dry season flow of Tista river, a tributary of Brahmaputra, to meet the water requirements of the twin Tista Projects in Bangladesh and India, is a source of tension between the two countries.

Through *New Indian line*, India plans to divert water from the Brahmaputra to the Ganges basin (see Figures 4 and 5; Publication V). To exploit the hydropower and water storage potential, this plan involves construction of dams and reservoirs in

the Brahmaputra basin area in Bhutan and India (Figures 5 and 7; Table 5). India wants to divert water from the Brahmaputra basin to the Ganges basin to increase agricultural production in other water scarce regions in India. India is striving to develop the enormous hydropower potential of the Brahmaputra basin for meeting the increasing energy demand of the country. India promotes Brahmaputra water resources and hydropower development through bilateral cooperation with Bhutan, excluding China and Bangladesh.

Bhutan has a history of friendly cooperation with India regarding hydropower development since 1961. Thus, for Bhutan, exploiting hydropower potential with financial and technical support from India is a prime concern.

On the other hand, China, which controls the headwaters of the Brahmaputra, wants to utilise the huge hydropower potential of Brahmaputra to meet its growing energy demand (see Table 5; Figure 7) and divert water from the Brahmaputra basin to other water scarce river basins of the country. Like India, China has also chosen a unilateral approach to the Brahmaputra basin's hydropower and water resources development, excluding India and Bangladesh.

4.3.3 Key Findings and Recommendations

The findings of Publication VII suggest that integrated Brahmaputra basin management based on regional cooperation between China, India, Bhutan and Bangladesh holds opportunities for mutual benefits. The four types of benefits – to the river, from the river, reducing the costs because of the river and beyond the river – could offer environmental, social, economic and political benefits for the riparian countries. The integrated management approach has the potential to promote sustainable development throughout the Brahmaputra basin as well as the Ganges basin.

Had the riparians been more attentive to the potential benefits of the integrated management of the Brahmaputra basin water resources, the regional development might have taken place earlier and perhaps most importantly, the split between Bangladesh and India over Ganges and Brahmaputra basins water management might have not developed, changing completely the character of South-Asian water conflicts.

Integrated and coordinated Brahmaputra water resources management offers prospects for development of the entire South Asia region. To achieve that, Publication VII recommends that the following issues are worth serious consideration:

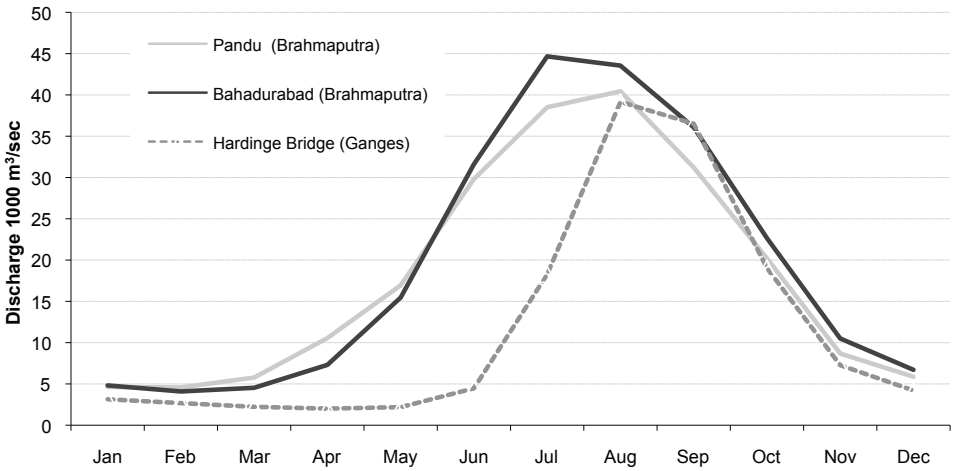


Figure 6 Brahmaputra and Ganges rivers: Average monthly discharge (1956-1979) measured at Pandu, Bahadurabad and Hardinge bridge.

1. Long-term energy security is at the heart of the Brahmaputra basin development due to its huge untapped hydropower potential. China and India are striving to develop the enormous hydropower potential of the Brahmaputra basin for meeting the increasing energy demand of the respective countries. However, the absence of bilateral and/or multilateral institutional arrangements and agreements between the riparian countries for the integrated management of Brahmaputra water resources constitutes an ongoing threat to future development plans within the basin.

2. Sustainable and integrated management of water and energy involving all co-riparians of the Brahmaputra basin, i.e. Bhutan, Bangladesh, India and China should be ensured. In this respect, streamlining water and energy policies of the riparian countries is utmost important. Internationally accepted principles of integrated water resources management (IWRM) need to be addressed properly in the national water policies. Publications I, II and III identified and analysed these principles in detail. Rahaman and Varis (2007) analysed to what extent IWRM principles are incorporated in the national water policies of India (2002) and Bangladesh (1999). The study concludes that although these policies are a good beginning, certain fundamental principles of IWRM are not addressed properly in those policies e.g. good governance, impact of climate change on water resources, river basin management plan and transboundary cooperation, and sharing data and information regionally. Addressing the internationally agreed IWRM principles properly in national water policies might contribute to streamlining different policies and legal, institutional and governance frameworks related to IWRM and hence, might promote the implementation of IWRM principles and plans (cf. Siddiqi & Tahir-Kheli, 2004: 91-92, 101, 168).

3. Due to geographical proximity and huge hydropower potential that is around 123000 MW, Nepal and Myanmar are also relevant for ensuring regional energy security. So cooperating with Nepal and Myanmar regarding hydropower development to enhance regional energy security might also be a worthwhile consideration.

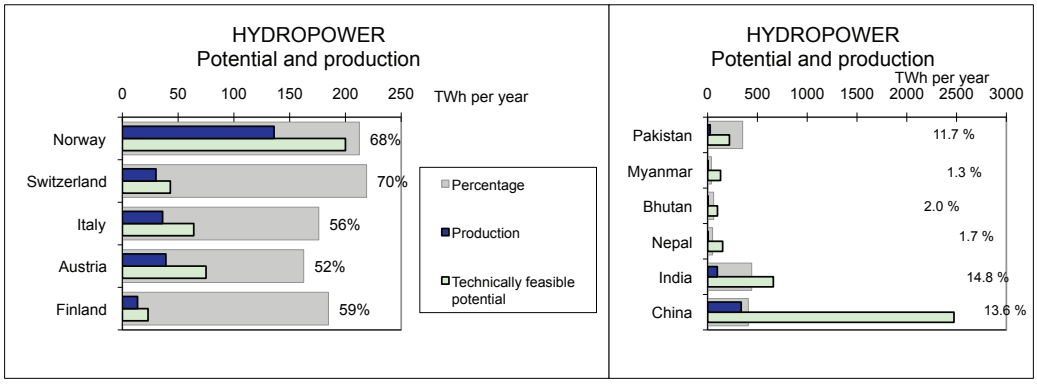


Figure 7 Hydropower potential and production from hydro plants (at end-2005) in some developed countries (on the left) and Ganges and Brahmaputra basins and neighbouring countries (on the right). Source: WEC, 2007:277-291.

4. Sharing hydro-meteorological, physical and environmental data among riparian countries is very important. Although China constitutes 51.10% of the Brahmaputra basin, due to lack of data and information, most previous studies, including this one, left out in-depth discussion of Brahmaputra basin water resources and development plans in China. This is true for India as well where key data regarding Brahmaputra and Ganges basin water resources are classified (cf. Fairless, 2008:280; Ohja & Singh, 2005:2; Publication V). Recognising that sharing of information and data is crucial and that in the world there exist both effective and non-effective examples of data sharing mechanisms, it would be worthwhile to undertake further research to provide guidelines for a data sharing mechanism that would possibly suit and become workable in the context of the Brahmaputra river basin.

5. Internationally accepted transboundary water resources management principles, e.g., theory of limited territorial sovereignty; principle of equitable and reasonable utilisation; obligation not to cause significant harm; and principles of cooperation, information exchange, notification, consultation and peaceful settlement of disputes could serve as guidelines and framework for further dialogue for ensuring effective integrated water resources management of international river basins (for details see Publication IV). Both India's and China's plans overlooked the burning necessity of consulting with other riparian countries. Owing to the exclusion of other riparian countries, both plans would be a violation of internationally accepted transboundary water management principles identified in Publications IV and VI. To reduce conflict and utilise the full potential of integrated water resources management, future bilateral and multilateral treaties between the riparian countries should include these principles.

6. As the Brahmaputra region and all proposed dam sites are located in earthquake sensitive areas (ASC, 2008; Mirza et al., 2001:39; Publication V), sufficient care should be taken in terms of earthquake resistant design, constant vigilance during maintenance and construction, rehabilitation and resettlement of the displaced people and downstream impact in the event of dam breach during flood time.

5 CONCLUDING REMARKS

Water research and science play an important role in advancing the principles of IWRM and the implementation of the process (UN, 2008:54). This requires a solid theoretical and practical understanding of the IWRM concept, associated principles and continuous research in different international, regional, national and local contexts. This thesis makes an attempt to develop and advance the understanding of IWRM principles and to identify the constraints and opportunities of implementing IWRM concept.

The key findings from the appended publications are summarised in sections 3 and 4 and elaborately presented in each appended publication. The general concluding remarks of this thesis, based on seven appended publications (I-VII), can be summarised in the following points:

1. Over the last three decades, world water professionals have developed the principles of IWRM in major international water events. And yet, in practice, implementation of the IWRM principles is challenging. The results from two case studies on the EU Water Framework Directive (2000) and the Mexico World Water Forum's Ministerial Declaration (2006) suggest that international and regional water policies and declarations often take a rather narrow view of the concept and have largely failed to incorporate the internationally accepted IWRM principles (Publications II and III). At policy level, there is a huge gap between theoretically agreed principles of IWRM and their implementation.

2. Future challenges remain in reducing the gap between theoretically agreed principles of IWRM and their implementation. As IWRM is a process where the IWRM principles need to be continuously developed, this thesis identified, but is not limited to, seven principles and approaches that need to be addressed by water professionals far more carefully than in the contemporary guidelines to facilitate the IWRM implementation process. These are: privatization, water as an economic good, transboundary river basin management, restoration and ecology, fisheries and aquaculture, lessons learned from past IWRM experience and the spiritual and cultural aspects of water (Publication I).

3. To promote IWRM implementation in international river basins including the Ganges and Brahmaputra basins, this thesis identified, but is not limited to, seven transboundary water resources management principles that could serve as guiding principles and framework for further dialogue among the riparian countries. These are: the principle of equitable and reasonable utilization, obligation not to cause significant harm, principles of cooperation, information exchange, notification, consultation and peaceful settlement of disputes (Publication IV, VI). The IWRM concept should consider including and acknowledging these principles as a prerequisite for integrated transboundary water resources development and management (Publications IV, V, VI and VII).

4. In-depth case studies from the Ganges and Brahmaputra river basins in South Asia

suggest that in international river basins, it is imperative to coordinate all water related development plans and aspirations of riparian nations to promote implementation of the IWRM concept (Publications V and VII).

5. Addressing temporal and spatial distribution of water resources and hydropower ambitions of riparian nations are the two key driving forces behind integrated water resources development and management along the Ganges and Brahmaputra river basins (Publications V and VII).

6. The analyses presented and steps suggested in this thesis could reduce the water conflicts, promote cooperation and facilitate regional development through efficient and integrated water development and management along the Ganges and Brahmaputra river basins (Publications V, VI and VII).

7. It is widely accepted that cooperation among the riparian countries is vital for promoting integrated water resources development and management along the transboundary river basins. However, it is obvious that cooperation among riparian countries always seems challenging. The case studies from the Ganges and Brahmaputra river basins suggest that, to promote cooperation and implement IWRM in international river basins, shifting the focus from the *water sharing approach* to the *benefit sharing approach* among the riparian countries might produce better results (Publications V and VII).

8. The case studies from the Ganges and Brahmaputra river basins suggest that, to promote IWRM implementation in transboundary river basins, there needs to be a greater focus on institutional arrangements for data sharing and joint management and transboundary water development and management agreements (Publications I, IV, V and VII).

In order to identify the current implementation status of IWRM principles at policy level, this thesis analyses the outcomes and requirements of the International Conference on Water and Environment (1992), Chapter 18 of Agenda 21 (Rio de Janeiro, 1992), Second World Water Forum (2000), European Union Water Framework Directive (2000), International Conference on Freshwater (2001), World Summit on Sustainable Development (2002) and Third World Water Forum (2003), Fourth World Water Forum's Ministerial Declaration (Mexico, 2006). It is suggested that future research should analyse other international, regional and national water policies and declarations to develop the IWRM concept and associated principles.

At field level, this thesis analyses the constraints and opportunities of IWRM implementation in two international river basins. It focuses on international macro issues related to IWRM in the Ganges and Brahmaputra basins, while acknowledging that research on micro level issues are also imperative for facilitating IWRM implementation in all international river basins. Each river basin is unique in its characteristics and problems as well as contemporary management approaches and potential solutions to future challenges. So, further research is recommended in other river basins focusing on linking international, national and local level issues to advance the IWRM implementation process.

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ANNEX I: LIST OF ABBREVIATIONS

The following abbreviations have been used in the text:

EU WFD	European Union Water Framework Directive
GWP	Global Water Partnership
ICFW	International Conference on Freshwater
ICWE	International Conference on Water and Environment
IWRM	Integrated Water Resources Management
SADC	South African Development Community
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNECE	United Nations Economic Commission for Europe
WSSD	World Summit on Sustainable Development
WWF	World Water Forum

INTEGRATED WATER RESOURCES MANAGEMENT: Constraints and opportunities with a focus on the Ganges and the Brahmaputra River Basins

Muhammad Mizanur Rahaman

Dissertation for the degree of Doctor of Science in Technology

The key aims of this thesis are to identify the constraints and opportunities of implementing the integrated water resources management (IWRM) concept at both the policy and field level. IWRM has been chosen as a focus of this study as all contemporary international conferences, summits, regional water policies and declarations promote the IWRM concept for the effective and efficient management of water resources.

The thesis has two parts. The first part reviews the evolution of the IWRM concept and the principles that have been developed at international conferences over the last three decades. Through two case studies on the EU Water Framework Directive (2000) and the Fourth World Water Forum's Ministerial Declaration (2006), an attempt is made to analyse the current implementation status of IWRM principles in practice. The findings suggest that existing policies tend to take a rather narrow view of the concept and have largely failed to incorporate the principles. This part also identifies the seven future challenges in implementing IWRM in practice.

Water resources management is multidimensional in nature. In transboundary river basins, implementing the IWRM concept is even more complex as it involves more than one sovereign nation sharing the same water. The second part of the thesis focuses on implementation of IWRM in the transboundary river basin context. This part provides in-depth analyses focusing on the integrated management of the Ganges and Brahmaputra river basins that are shared by China, Nepal, Bhutan, India and Bangladesh. It identifies the various dimensions of water conflict among the riparian countries and their views on integrated management of the basins. It analyzes the existing bilateral treaties between the riparian countries and identifies the constraints and benefits of integrated water management along the basins. Practical recommendations for the integrated management of the Ganges and Brahmaputra basins are formulated. The findings suggest that it is imperative to coordinate all water related development plans and aspirations of riparian nations through effective transboundary cooperation to promote implementation of the IWRM concept in the Ganges and Brahmaputra basins. This thesis also identifies the principles associated with transboundary water resources management that are necessary to facilitate IWRM implementation in international river basins.

Water research and science play an important role in advancing the principles of IWRM and the implementation of the process. This thesis is an attempt to contribute to this process and facilitate integrated Ganges and Brahmaputra basins management.

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