Water and Environment Centre

Sana'a University
Republic of Yemen

Course:

Integrated Groundwater Management

Date: December 2008

COURSE OUTLINE

Contents
The need for managing rather than just developing groundwater is increasingly clear. Groundwater is the main stay of large agricultural economies and a major source of drinking water in many rural areas, towns and even mega cities. However, declining water tables, saline water intrusion, increased levels of arsenic and fluoride in drinking water, land subsidence are all pointers to resource management that needs to be set right.

During the course students will get an understanding of the role of groundwater in relation to IWRM. Block 1 is an introduction on Integrated Groundwater Management. Block 2 focuses on technical aspects of groundwater management. Lectures will be given on among others groundwater hydraulics, groundwater exploration, groundwater pumping and groundwater wells. This block will increase the technical knowledge of the students on groundwater management. Block 3 discusses the role of the state in IGWM by explaining the functioning of institutional / Policy / Law systems which include traditional and present groundwater regulations. This will be followed by explaining the functioning of socio–economic systems and management strategies followed by the state. Block 4 discusses IGWM aspects like participation, development, planning process and the way towards sustainable integrated groundwater resources management. During Block 5 students apply knowledge obtained in the previous blocks on the Sana'a Basin Case Study.

IGWM in the broader context
Since certain government policies and development directions often lead to depletion of water resources, changing these policies and directions is often the essential initial step toward sustainability. During the past few decades, the Government of Yemen has adopted a country-wide supply-orientated water resources management strategy to secure the needs for water for different purposes. Groundwater was viewed as the natural exploitable resource to induce socioeconomic development. The aridity of the region did not support other options. Groundwater resources development has the advantage of scale over surface-water development. It does not require large-scale projects such as dams, canals and other engineering structures. In comparison, surface-water utilization requires large diverting and regulating structures along with the technical expertise needed to design, construct and operate them. Another advantage was the widespread occurrence of groundwater in the different regions of the country giving the government a good opportunity to reach out to remote communities with `tangible' development. In addition, the development of groundwater resources in any region of the country was accessible by many competing users with the simple technology of drilling a well. Coupled with the need for irrigation water to support agricultural development was the need to satisfy the growing domestic demand for water.

The concerns over groundwater utilization have the ring of the infamous 'tragedy of the commons' - unlimited access to a common pool, leading to its decline. Solutions advocated remind one of the old 'tragedy' discussions: defining access - registration of abstraction points, issuing permits, defining groundwater rights (even tradable groundwater rights). But the real drama appears to be that not many of these rights based solutions are around in practice.

Introduction to Hydrology and Hydrology of Yemen are a basis for the technical features of this topic, on which IGWM will go further. Rules and regulations in water management and water economics also play an important role in integrated ground water management.

Objectives

The objectives are to provide knowledge and understanding of the principles of groundwater concepts, groundwater exploration, extraction, evaluation, management and developments.

TABLE OF CONTENTS

Block 1:

Introduction to IGWM

1 INTRODUCTION

Desirable integration and possible overlap with first semester courses:
F Water use in agriculture 40 hrs

Compulsory literature:

Shah, Tushaar, Jacob Burke and Karen Villholth. 2007. "Groundwater: a global assessment of scale and significance." In David Molden (ed.) *Water for food, water for life: A comprehensive assessment of water management in agriculture*. (pp. 395-423). London: Earthscan, and Colombo: International Water Management Institute

Recommended literature:

FAO, 2003. "Groundwater Management." *The search for practical approaches.* Food and Agriculture Organization of the United Nations. Water Report 25, Rome, 2003.

GWP. 2000b. *Integrated water resources management*. TAC Background Papers No 4. Stockholm: GWP.

2 PRINCIPLES OF IGWM CONCEPTS

Compulsory literature:

Tuinhof, Albert, Charles Dumars and Stephen Foster, 2006. "Sustainable groundwater management." *Concepts and tools*. The World Bank. GW Mate, Briefing Note Series, Note 1, 2006.

Recommended literature:

White, Gilbert F. 1998. "Reflections on the 50-year international search for integrated water management." *Water Policy* 1(1): 21-27.

Allan, J. A. 2006. "IWRM: The new sanctioned discourse?" In Peter P. Mollinga, Ajaya Dixit and Kusum Athukorala (eds) *Integrated water resources management: Global theory, emerging practice and local needs*. (pp. 38-63). New Delhi: SAGE Publications.

Block 2:

Technical Aspects on Groundwater Management

3 GROUNDWATER UTILISATION

Desirable integration and possible overlap with first semester courses:
F Water use in agriculture 40 hrs

Compulsory literature:
Llamas, Ramón, William Back and Jean Margat. "Groundwater use." *Equilibrium between social benefits and potential environmental costs.*

Recommended literature:
Shah, Tushaar, David Molden, R. Sakthivadivel and David Seckler, 2000. "The Global Groundwater Situation." *Overview of Opportunities and Challenges*. Colombo, Sri Lanka: International Water Management Institute

Foster, Stephen, Marcella Nanni and Karin Kemper, 2006. "Sustainable groundwater management." *Concepts and tools*. The World Bank. GW Mate, Briefing Note Series, Note 11, 2006.

4 GROUNDWATER HYDROLOGY

Desirable integration and possible overlap with first semester courses:

B Introduction to hydrology	40 hrs
E Hydrology of Yemen	40 hrs

Compulsory literature:
Some chapters of the book:
Bear, J., 1979. "Hydraulics of Groundwater." J Bear, McGraw-Hill Companies,1979.

Recommended literature:
Foster, Stephen and Albert Tuinhof, 2006. "Characterisation of Groundwater Systems." *Key concepts and frequent misconceptions*. The World Bank. GW Mate, Briefing Note Series, Note 2, 2006.

5 WELL TYPES, DRILLING, DEVELOPMENT AND DESIGN

Compulsory literature:
Printed version of: "Groundwater Infrastructure."

All chapters of the book:
Bom, Gert Jan, Ibrahim Hafeezur Rehman, David van Raalten, Rajeshwar Mishra and Frank van Steenbergen, 2002. "Technology, innovation and promotion in practice: pumps, channels and wells." *Reducing fuel consumption, emissions and costs*. GJ Bom, Tata energy research institute, 2002.

Recommended literature:

6 GROUNDWATER OVEREXPLOITATION

Possible overlap with "Water and Environment" (Boudewijn's course)

Desirable integration and possible overlap with first semester courses:
D Water and environment 40 hrs

Compulsory literature:
Custodio, Emilio, 2002. "Aquifer overexploitation." *What does it mean?* Springer-Verlag, 2002.

Changming, Liu and Yu Jingjie, 2001. "Groundwater Exploitation and its impact on the Environment in the North China Plain." International Water Resources Association. Water International, Volume 26, Number 2, Pages 265-272, 2001.

Recommended literature:
Braadbaart, Okke and Frederick Braadbaart, 1997. "Policing the Urban Pumping Race." *Industrial Groundwater Overexploitation in Indonesia*. Elsevier Science Ltd., 1997.

Shah, Tushaar, Aditi Deb Roy, Asad S. Qureshi and Jinxia Wang, 2003. "Sustaining Asia's groundwater boom: An overview of issues and evidence." Natural Resources Forum 27, Pages 130-141, 2003.

7 GROUNDWATER EXPLORATION

Compulsory literature:
Some chapters of the book:
Lehr, Jay H. and Robert A. Bisson, "Modern groundwater Exploration."

Recommended literature:

Block 3:

The Role of the Government in IGWM

8 FUNCTIONING OF INSTITUTIONAL-, POLICY-, AND LAW SYSTEMS

Desirable integration and possible overlap with first semester courses:
H Water rights and policies 80 hrs

Compulsory literature:

Nanni, Marcella, Stephen Foster and Charles Dumars, 2006. "Groundwater Legislation & Regulatory Provision." *From customary rules to integrated catchment planning*. The World Bank. GW Mate, Briefing Note Series, Note 4, 2006.

Mollinga, Peter P. 2001. "Water and politics: levels, rational choice and South Indian canal irrigation." *Futures* 33(8-9): 733-752.

Recommended literature:

Merrey, Douglas J., Ruth Meinzen-Dick, Peter P. Mollinga and Eiman Karar. 2007. "Policy and institutional reform: The art of the possible." In David Molden (ed.) Water for food, water for life: A comprehensive assessment of water management in agriculture. (pp. 193-231). London: Earthscan, and Colombo: International Water Management Institute.

Rap, Edwin. 2004. *The success of a policy model. Irrigation management transfer in Mexico*. Ph.D. dissertation, Wageningen University, Wageningen, the Netherlands.

Burchi, Stefano. 1991. "Current developments and trends in the law and administration of water resources – a comparative state-of-the-art appraisal." *Journal of Environmental Law* 3(1): 69-91.

9 TRADITIONAL AND PRESENT GROUNDWATER LEGISLATION IN YEMEN

Desirable integration and possible overlap with first semester courses:
H Water rights and policies 80 hrs

Compulsory literature:
Steenbergen, Frank van. "Local Groundwater Regulation." Water Praxis Document Nr. 14.

Recommended literature:
Carduño, Hector, Stephen Foster and Charles Dumars, 2006. "Groundwater Abstraction Rights." *From theory to practice*. The World Bank. GW Mate, Briefing Note Series, Note 5, 2006.

Gleick, Peter. 1998. "The human right to water." *Water Policy* 1(5): 487-503, 1998.

Krishnan, Jyothi. 2007. *Enclosed waters: Property rights, technology and ecology in the management of water resources in Palakkad, Kerela*. Ph.D. dissertation Wageningen University, Wageningen, the Netherlands.

G

10 THE FUNCTIONING OF THE SOCIO-ECONOMIC SYSTEM

Desirable integration and possible overlap with first semester courses:

L Gender and water	40 hrs
G Water value / economics	60 hrs

Compulsory literature:

Allan, J. A. 2005. "Water in the environment/socio-economic development discourse: sustainability, changing management paradigms and policy responses in a global system." *Government and Opposition* 40(2): 181-199.

Recommended literature:

Foster, Stephen and Daniel P. Loucks, 2006. "Non-renewable groundwater resources." *A guidebook on socially sustainable management for water-policy makers*. UNESCO, 2006.

Mukherji, Aditi and Tushaar Shah, 2005. "Groundwater socio-ecology and governance: a review of institutions and policies in selected countries." Springer-Verlag, 2005.

11 WATER MANAGEMENT STRATEGIES FOLLOWED BY THE STATE

Desirable integration and possible overlap with first semester courses:

K Water use in urban and rural areas	40 hrs
N Sanitation and waste water treatment	40 hrs

Compulsory literature:

Al Sakkaf, Rafik A., Yangxiao Zhou and Michael J. Hall, 1999. "A Strategy for Controlling Groundwater Depletion in the Sa'dah Plain, Yemen." Water Resources Development, Vol. 15, No. 3, pages 349-365, 1999.

Foster, Stephen and Albert Tuinhof, 2006. "Groundwater Management Strategies." *Facets of the integrated approach*. The World Bank. GW Mate, Briefing Note Series, Note 3, 2006.

Scott, Christopher A. and Tushaar Shah. 2004. "Groundwater overdraft reduction through agricultural energy policy: Insights from India and Mexico." *International Journal of Water Resources Development* 20(2): 149-164.

Recommended literature:

Molle, François and Jeremy Berkoff. 2006. *Cities versus agriculture: Revisiting intersectoral water transfers, potential gains and conflicts*. Comprehensive Assessment of Water Management in Agriculture Research Report 10. Colombo, Sri Lanka: IWMI.

12 GROUNDWATER CONFLICTS

Compulsory literature:
Starr, Joyce R., 1991. "Water Wars." *Foreign Policy* 82 (Spring 1991): 17-36.

Recommended literature:
Dolatyar, Mostafa and Tim S. Gray, 2000. "The Politics of Water Scarcity in the Middle East." Environmental Politics, 9:3, Pages 65-88, 2000.

Gleick, Peter. 1993. *Water in crisis. A guide to the world's freshwater resources*. Oxford: Oxford University Press.

Bulloch, John and Adil Darwish. 1993. *Water wars: Coming conflicts in the Middle East*. London: Gollancz.

Block 4:

IGWM Aspects

13 IGWM PARTICIPATION

Desirable integration and possible overlap with first semester courses:
M Water and public participation 40 hrs

Compulsory literature:

Carduño, Hector, Marcella Nanni and Stephen Foster, 2006. "Stakeholder Participation in Groundwater Management." *Mobilising and sustaining aquifer management organisations*. The World Bank. GW Mate, Briefing Note Series, Note 6, 2006.

Recommended literature:

Sandoval, Ricardo. 2004a. "A participatory approach to integrated aquifer management: The case of Guanajuato State, Mexico." *Hydrogeology Journal* 12(1): 6-13.

Groenfeldt, David. 1998. *Handbook on participatory irrigation management*. Washington, D.C.: The Economic Development Institute of the World Bank.

Wester, Philippus, Jaime Hoogesteger-van Dijk and Hans Paters. 2007. "Multi-Stakeholder Platforms for surface and groundwater management in the Lerma-Chapala Basin, Mexico." In Jeroen Warner (ed.) *Multi-Stakeholder platforms for integrated water management*. (pp. 151-164). Aldershot, UK: Ashgate Publishers.

14 THE WAY TOWARDS SUSTAINABLE AND INTEGRATED GROUNDWATER RESOURCES MANAGEMENT

Compulsory literature:

IUCN. 2000. Vision for water and nature: A world strategy for conservation and sustainable management of water resources in the 21st Century. Gland, Switzerland: IUCN.

Recommended literature:

Kemper, Karin, Stephen Foster and Hector Garduño, 2006. "Economic Instruments for Groundwater Management." *Using incentives to improve sustainability*. The World Bank. GW Mate, Briefing Note Series, Note 7, 2006.

GWP. 2000a. *Towards water security: A framework for action*. Stockholm: GWP.

Falkenmark, Malin and Jan Lundqvist. 1998. "Towards water security: Political determination and human adaptation crucial." *Natural Resources Forum* 21(1): 37-51.

15 IGWM PLANNING PROCES

Compulsory literature:

Minciardi, Riccardo, Michela Robba and Roberto Sacile, 2002. "Methods and Models for Sustainable Groundwater Planning and Management." University of Genova, CIMA, 2002.

Recommended literature:

HRH The Prince of Orange and Frank R. Rijsberman. 2000. "Summary report of the 2nd world water forum: From vision to action." *Water Policy* 2(6): 387-395.

16 IGWM DEVELOPMENT

Compulsory literature:

Jha, Madan K., Alivia Chowdhury and V.M. Chowdhury, 2006. "Groundwater Management and Development by Integrated Remote Sensing and Geographic Information Systems: Prospects and Constraints." Springer Science + Business Media B.V., 2006.

Recommended literature:

Abdelrhem, Isam Mohamed, Rashid Kahlim and Ismail Amiruddin, 2008. "Integrated Groundwater Management for Great Man-made River Project in Lybia." European Journal of Scientific Research, 2008.

Crifasi, Robert R. 2002. "The political ecology of water use and development." *Water International* 27(4): 492-503.

Gleick, Peter. 2000. "The changing water paradigm: A look at twenty-first century water resources development." *Water International* 25(1): 127-138.

Molden, David et al., 2007. "Trends in water and agricultural development." IWMI, Part 2, Chap 2, Pages 57-89, 2007.

Rockström, Johan and Eric Kempt-Benedict, 2007. "Looking ahead to 2050." IWMI, Part 2, Chap 3, Pages 91-145, 2007.

Seckler, David. 1996. *The new era of water resources management: From "dry" to "wet" water savings*. IMII Research Report 1. Colombo, Sri Lanka: IMII.

Block 5:

Sana'a Basin Case Study

SANA'A BASIN CASE STUDY