PERGAMON

Physics and Chemistry of the Earth 27 (2002) 831–838

PHYSICS and CHEMISTRY of the EARTH

www.elsevier.com/locate/pce

A comparison between conventional and integrated water resources planning and management

Jonathan I. Matondo *

University of Swaziland, Private Bag 4, Kwaluseni, Swaziland

Abstract

Air, land and water are the three fragile components of the Spaceship Earth. These three components are highly integrative resources and therefore, must be properly planned and managed in order to ensure adequate public health, food supplies and transportation. The quality of life is directly dependent on how well these resources are planned and managed for sustainable development. The above three resources are highly integrated and thus the need for multi-purpose water resources planning and management. Multi-purpose water resources planning and management also emerged as a result of an increase in competing and conflicting water uses and due to rapid population growth and rising expectations of a better life.

This paper discusses the conventional and integrated water resource planning and management approaches for sustainable development. The author agues that, both approaches if implemented very well are geared to deliver the same end results 'sustainable development'. However, the paper concludes that, both approaches have failed to deliver the end results due to a missing link. This missing link in both approaches is the institutional framework that coordinates water resources planning and management responsibilities and activities at all levels of government.

Keywords: Comparison; Conventional; Integrated; Water management; Institutional framework

1. Introduction

The fragile components of Spaceship Earth are principally air, land and water. These three highly interactive resources must be properly managed in order to ensure adequate public health, food supplies and transportation. The quality of human life is directly dependent on how well these resources are managed. Water is the most important catalyst for human development. It is a major input in almost all sectors of the human endeavour. Ancient civilizations grew up in the river valleys of Tigris and Euphrates, the Nile, Indus, Hwang Ho etc. where there was plenty of water. During those days the planning and management of the water resources were for single uses. As time passed on it was recognized that resources were integrated and therefore, the need for longer-range planning that would include multi-purpose systems resources. Multi-purpose water resources planning also emerged as a result of an increase in the competing and conflicting water uses and due to rapid population growth and rising expectations of a better life.

The conventional water resources planning and management is from Top Bottom approach coupled with public hearing in developed countries. While in developing countries it is the experts and the decision makers (usually the politicians) who have much say on the planning and implementation of water resources projects. The public has no much say but to accept what is being planned for them.

Integrated water resources planning and management (IWRPM) is participatory, technically and scientific informed and is taken at the lowest level, but within the framework at the catchment, basin and aquifer level which are the natural units by which nature manages water. Stakeholder participation is the key point in IWRPM approach. That is the empowered community has the responsibility to address local issues in a coordinated and integrated way.

The earlier water resource project plans did not take into consideration of the environment and thus had negative effects to the environment. The world society recently has put emphasis on the need in water resources planning and management for consideration of the

* Tel.: +268-518-4011; fax: +268-518-5276.
E-mail address: matondo@uniswacc.uniswa.sz (J.I. Matondo).

1474-7065/02/$ - see front matter © 2002 Published by Elsevier Science Ltd.
PII: S1474-7065(02)00072-4

quality and aesthetic integrity of the environment. The environmental impact assessment is now an integral part of a water resources plan. According to Loucks (2000), 'Sustainable water resources systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity'.

It has been established by scholars that water resources problems are going to be more complex in the future world wide (Simonovic, 2000; Wurbs, 1998; Singh, 1995). Population growth, climate variability, regulatory requirements, project planning horizons, temporal and spatial scales, socio and environmental considerations, and transboundary considerations all of these contribute to the complexity of water resources planning and management problems (see Fig. 1). Systems analysis has been established as one of the tools for solving complex water resource problems (Dantzing, 1963; Hillier and Lieberman, 1990; Loucks et al., 1981). According to Simonovic (2000), complex water resources planning problems heavily rely on systems thinking, which is defined as the ability to generate understanding through engaging in the mental model-based processes of construction, comparison and resolution through the use of computer software tools such as STELLA, DYNAMO, VENSIM, POWERSIM (High Performance Systems, 1992; Lyneis et al., 1994; Ventura Systems, 1995; Powersim Corporation, 1996).

This paper presents a discussion on the Conventional and IWRPM approaches. The application of systems analysis in water resources planning and management is also presented. The missing link in both approaches for water resources planning and management will is discussed.

2. Conventional water resources planning and management

Planning is involved in virtually all human endeavours. Water resources planning as defined by the USA

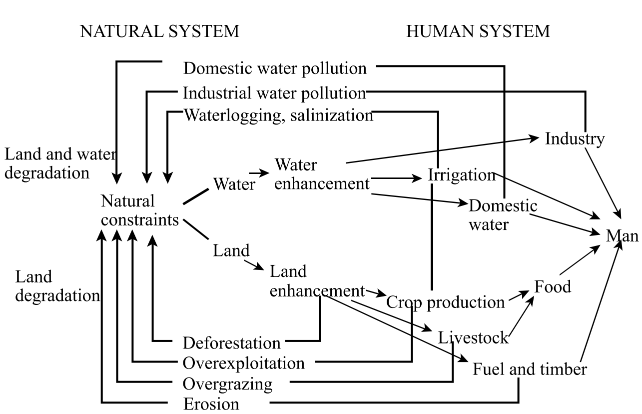

Fig. 1. Complex interactions and feedbacks between the natural and human systems. (Falkenmark, 1986).

National Water Committee (1966) "is the creative and analytical process of (a) hypothesizing sets of possible goals, (b) assembling needed information to develop and systematically analyze alternative courses of actions for attainment of such goals, (c) displaying the information and the consequences of alternative actions in an authoritative manner, (d) devising detailed procedures for carrying out the actions, and (e) recommending courses of action as an aid to the decision-makers in deciding what set of goals and courses of action to pursue".

A goal is a desirable state of affairs where a person or an integrated group of persons is actively striving to achieve. The first step in water resources planning is that of analyzing the possible sets of goals which the community or country is striving to achieve for the benefits of its citizens and the environment. The general goal in water resources planning is the improvement of human welfare. A lot of data is required in the planning of water resource projects (hydrological, economic, social economic, demographic, physical, meteorological, etc.). All the above information is required for the analysis of alternative plans. The major objectives in water resources planning are: national economic development, regional development, environmental quality and social well being. Therefore, each alternative plan should display the beneficial and adverse effects on all the four major objectives. The definition also emphasizes that each alternative plan should have detailed procedures for carrying out the actions. A plan should also have the recommendations on the possible courses of actions to pursue. This is intended to help the decision markers to make the right decision. We should also bare in mind that engineers, water resource planners etc are not the decision makers. This responsibility rests in the hands of decision makers who are the politicians. Therefore, the politicians must be fed with the right information.

The total planning process involves goals, objectives, activities, and resources of all kinds that can seldom be considered independently. Meeting the needs of the people requires consideration of land use, water, housing, transportation, education, and many other sectors of human endeavours. The general interrelated hierarchies in the planning process can be described by the following classifications of planning activities as illustrated in Table 1.

2.1. Planning jurisdictions

The planning, development and management of water resources can be carried out at international level. This is especially the case when a water course crosses several national boundaries, such as the Zambezi river, Nile river etc. Planning for water resources can also be carried out at national, regional, District and at village level.

Table 1
Classification of water resources activities

Planning jurisdiction	Scope of planning programs	Stages of planning	Planning area
International	Multi-sectorial	Policy planning	Urban
National/ministeraial	Sectorial	Framework planning	Basin
Regional, district	Functional	General appraisal planning	
Village level/local		Implementation planning	

2.2. Scope of planning programs

The scope of planning programmes as indicated above are: Multi-sectorial, sectorial and functional. Multi-sectorial planning is the coordinated planning for all sectors of the public endeavour, such as land use, housing, education, water resources, energy supply etc. Sectorial planning is the integrated planning for all functions within one sector, such as water resources. While, functional planning is the planning to meet a specific need within one sector such as flood control, hydro power etc.

2.3. Stages of planning

The stages of planning as indicated in Table 1, are: Policy, framework, general appraisal and implementation planning. Policy planning is the overall goals and program objectives, policy development, overall budget and priority analysis, dissemination of program guides etc. Framework or reconnaissance planning is the identification of general problems and needs, outlining a range of possible alternative futures, inventory of available resources and general opportunities, assessment of overall adequacy of resources, and determination for further investigation. General appraisal planning is the broad evaluation of alternative measures for meeting hypothesized goals and objectives, with recommendations for action plans and programs by specific entities. Implementation planning is the investigations of a specific structural or non-structural measure, or a system of measures, in sufficient detail to determine whether it will meet established goals, objectives, and criteria and if so, that it is physically possible of implementation within the estimated costs and within limits of financial feasibility.

2.4. The need for multi-sectorial planning

The USA National Water Committee (1966) explains the need for multi-sectorial planning as follows: The increasing complexity of regional economies and the increasing degree of interrelationships between segments of society virtually require that plans for the water resources sector be consistent with and complementary to plans being developed for other sectors of the human endeavour.

Multi-sectorial planning is essential if

(a) sectorial plans, such as water resource management plans, are to be properly related to planning in other sectors such as agricultural;
(b) the various sectorial plans are to be properly related to existing and proposed land-use development; and
(c) all sectorial plans are to be related to basic societal development goals and objectives.

Such multi-sectorial planning can avoid costly inconsistencies and conflicts; assure consideration of the true benefits and costs of alternative plan proposals—including social costs to be determined; and help identify otherwise unforeseen secondary and tertiary effects of plan proposals.

The interrelationships and sequence of multi-sectorial, sectorial and functional planning are significant. Properly performed, multi-sectorial planning should precede sectorial planning and sectorial planning should precede functional planning.

The probable complexities and interrelationships of the future such as the potential for competition between irrigation and municipal water supply and the opportunities for recycling of wastewater for reuse as water supply emphasize the importance—the virtual necessity—that functional planning be consistent with plans for other functions in the water sector. Therefore, all phases of sectorial planning should fit together to conform to a multi-sectorial plan and that all phases of functional planning fit together to conform to a sectorial plan (USA National Water Committee).

It has been mentioned that water is involved in most all sectors for the human endeavour. Water resources planning and management decisions can have environmental, physical, social, and economic impacts that are widespread and pervasive. It can be seen from the above that, water resources planning and management involves many disciplines such as: engineering, economics, social science etc. Therefore, water resources planning and management is carried out by a team effort (multidisciplinary). Solutions to complex water resources planning and management problems requires the use of systems analysis.

2.5. Application of systems analysis

It has already been mentioned that, water sources problems are complex in nature. Systems analysis has been established as a suitable tool for solving water resource problems. Systems analysis is defined as: a rational approach to arriving at management decisions for a particular system, based on the systematic and efficient organization and analysis of relevant information. There are a number of terms which are used synonymously with systems approach and these include: systems engineering, operations research, operations analysis, management science; cybernetics and policy analysis. Hall and Dracup (1970) define Systems Engineering as the art and science of selecting from a large number of feasible alternatives, involving substantial engineering content, that particular set of actions which will accomplish the overall objectives of the decisions markers, within the constraints of law, morality, economics, resources, political and social pressures, and laws governing the physical, life and other natural sciences.

During the planning stages, the issues here is to find the optimal firm water (W), firm power (P) and flood reserves that will meet the water and power demand and offer flood control reserves while maximizing the overall benefits. This is what is often referred to as the pre-contract studies problem in the conventional water resources planning and management. The optimization problem of the pre-contract studies is expressed as follows:

$$\text{Maximize} \quad b_w W + b_p P + \sum_{t=1}^{12} b_f V_{\text{flood},t}$$

$$\text{Subject to} \quad V_{t+1} = V_t + I_t + R_t + L_t - E_t - Q_t - N_t$$

where

$$Q_t = a_t W + q_t, \quad q_t \geqslant 0,$$

$$E_t = e_t A\left(\frac{V_t}{2} + \frac{V_{t+1}}{2}\right),$$

$$P_t = KQ_t h\left(\frac{V_t}{2} + \frac{V_{t+1}}{2}\right)\Delta t,$$

$$P_t = P_t P + \bar{P}_t \geqslant 0,$$

$$V_{\min} \leqslant V_t \leqslant V_{\max} V_{\text{spill}},$$

$$Q_{\min} \leqslant Q_t \leqslant Q_{\max},$$

$$P_{\min} \leqslant P_t \leqslant P_{\max},$$

$$V_{\text{flood},t} = V_{\text{spill}} - V_{\max}.$$

The above problem can be solved using any optimization technique (linear programming, dynamic programming, etc.). The solution to the above will yield the optimal values of firm water W^* and firm power (P^*), as well as the optimal value of $V_{\max}$ for each month t. It should be pointed out here that the releases to the natural channel are specified a priori. The releases to the natural channel (N_t) are required to meet the in stream water requirement, the water requirement for the sustainability of the riverine environment and the minimum water quality abatement. If a river crosses international boundaries, then N_t will also include the amount of water left for the downstream riparian state in addition to the above requirements.

The obtained firm water and power is useful information for engaging in contract negotiations with water and power users. The reservoir(s) has to be operated in really time in order to minimize contract violations at the same time maximize beneficial use of the reservoir(s). This is what is referred to as the post contract or real-time operational problem.

The optimization problem for post contract studies is expressed as follows:

$$\begin{array}{lll} \text{Minimize} & \sum_{t=1}^{T}(a_t W^* - Q_t)^2 & \text{if } Q_t \leqslant a_t W^* \\ & 0 & \text{if } (Q_t \geqslant a_t W^*)\mu_t \\ & +(b_t P^* - P_t) & \text{if } P_t \leqslant b_t P^* \\ & 0 & \text{if } (P_t \geqslant b_t P^*)\gamma_t \end{array}$$

where μ_t and v_t are appropriate weighting factors to establish operational priorities and a_t is a firm water distribution coefficient which, is expressed as follows:

$$a_t = \frac{D_t}{\sum_{t=1}^{12} D_t}$$

where D_t is the total water use for all the sectors in month t. The real-time operational problem is solved for periods of less than a month. The constraints are essentially the same as for pre-contract studies, except that they are defined over short time intervals. Forecasted stream flows are used in the real-time operational problem instead of the historical record or critical low flow period. Water resources management is basically an attempt to decide on how water should be allocated among the various conflicting and competitive uses without compromising the quality of the environment.

What can be summarized here is that, the conventional water resources planning is integrated in the sense that plans must fit into a multi-sectional plan. The plans are driven by the four major objectives namely: national economic development; regional development; social well being and environmental quality. The preservation of the natural environment is embedded in the environmental quality objective which is also preserved in the optimization problem for pre-contract and post contract studies. The requirement for an environmental impact assessment for each plan emphasizes environmental protection. Therefore, water resources planning and management if conventionally done well will lead to sustainable water resources development. However, it has been established that conventional water resources planning and management has failed to lead to sustainable water resources development (Falkenmark, 1993; SCOWAR, 1998). This has been the case especially in developing countries where environmental preservation has received less attention to communities who have to deal with the immediate realities of poverty. It is therefore, conceived that, IWRPM has come about as a result of the failure of the conventional water resources planning and management to produce sustainable water resources development, especially in developing countries.

3. Integrated water resources planning and management

It has been established that each body of water is a delicately balanced component of the landscape in a continuous interaction with the surrounding air and land. Therefore, water is intimately related to all mans' activities in the landscape and whatever occurs on the land and in the air also affects water (Kindler, 1992). IWRPM has also emerged from the perception that water is an integral part of the ecosystem, a natural resource, and a social and economic good (United Nations, 1992).

Many authors in the literature are concerned with IWRPM (Duda and El-Ashry, 2000; DWAF, 1998; Grigg, 1996) while others are concerned with integrated catchment management (Hu, 1999; Frago, 1998; Heathcote, 1998; DWAF, 1998; Mitchell and Hollick, 1993). The definition of IWRPM is the incorporation of the socio human factors, the economic issues and the ecological system. Which means that the society will continue to benefit from the utilization of the water resource while maintaining the environment and the resource base to meet the needs of the future generations. Integrated in IWRPM means that more than one sectorial interests are linked at both the operational and strategic levels. Integrated catchment management sets out to integrate, in a systems approach, all environmental, economic, and social issues, within the bounds of a river basin, into an overall management philosophy, process and plan (product). This is aimed at delivering the optimum possible mix of sustainable benefits for future generations and the communities in the area of concern, whilst protecting the natural resources which, are used by the communities and minimizing possible adverse social economic and environmental consequences.

> The above definitions on IWRPM and ICM seem to be talking of the same thing. Therefore, I have tended to go along with IWRPM and leave the catchment as the planning and management unit.

I have always tended to believe that, we should start from the planning level and then move to the management level. This is because if you have not planned, you may have nothing to manage (could be true or false). Therefore, integrated water resources planning is a process whereby the water utility determines the options that at least cost will provide its customers with the water related services that they demand rather than the water itself while maintaining the integrity of the environment (Howe and white, 1999). Integration here has the same meaning as in the conventional water resources planning. That is, all the sectors of the human endeavour, including land use and the environmental are taken into consideration. Integration is then seen here as the art and science of blending all the items above into a whole.

Water resources management is defined as the utilization of, existing and/or planned facilities and institutions in the most beneficial way through appropriate rules, policies and procedures to achieve greatest benefits through legal authority. At the private level, water resources management effectiveness is directly measured by the profits accruing while at the government level is measured by the achievements in the national economic development, environmental quality, regional development and social well being. The private sector is geared at the maximization of benefits from the utilization of the water resources. Therefore, without proper legislation and policies, environmental degradation is likely to take place if the management of the water resource is intrusted in the private sector. An example is the utilization of the Colorado river which leaves only a trickle of water to reach the Colorado delta, thus causing environmental and social degradation (Duda and El-Ashry, 2000).

Integrated water resources management plan has to take into consideration all the sectors of the human endeavour, land use and the environment. The benefits of integrating the various aspects of water resources management have been identified by many researchers, policy makers and water managers (Grigg, 1996).

According to Malano (1999) there are four major principles in IWRPM and these are:

- Sectoral (and sub-sectoral) integration that takes into account competition and conflicts among various users.
- Geographical integration.
- Economic, social and environmental integration that take into account of social, and environmental costs and benefits and
- Administrative integration that coordinates water resources planning and management responsibilities and activities at all levels of government.

The Global Water Partnership IWRM Toolbox has policy guidance and operational tools. The operational tools comprise of the enabling environment, institutions and management instruments. The collaboration of all institutions dealing with water is the driving force in Global water Partnership.

Postel and Lundin (1996) provides a full range of characteristics associated with IWRMS. Another activity which, has been associated with IWRMS is stakeholder participation (Balackmore, 1995). It has been pointed out by several researchers (Ashton et al., 1998; Savenije and Van der Zaag, 1998; World Bank, 1993) that, stakeholders should be informed about the planning, development and management of the water resource. Stakeholder participation under the conventional water resources planning especially in developed countries the USA in particular has been through public hearings. However, stakeholder participation through public hearings has not been possible in developing countries and this has led to the failure of many water schemes. However, community empowerment has been established to generate some sense of responsibility and thus sustainable development and management of water supply schemes.

All the factors and interactions in conventional and IWRPM have been presented. I have always thought that integrated is a catch word while multi-sectorial is the principle approach in the conventional water resources planning and management. Therefore integrated and multi-sectoral approaches have a lot in common and few differences, if any and if each is performed properly will yield the same results.

However the conventional and IWRPM approaches have failed to accomplish a sustainable water resources development and management. There is a vital link that is missing in both approaches which, is hindering or has hampered the sustainable utilization of the water resource in both developed and developing countries. Institutional framework is the missing link and is presented in the following section.

4. Institutional framework: the missing link

It has been pointed out that conventional water resources planning is usually isolated from land use planning, concentrating on water resources alone (Falkenmark, 1993; SCOWAR, 1998). However, I do not agree with them because as explained earlier, multi-sectoral planning is indeed IWRPM and it takes into consideration the land use issues and environmental conservation. Mitchell (1987) contends that "the process in adopting an integrated approach in the 1980s has been hesitant and unsystematic in part because of the absence of suitable models for implementation". However, at the turn of the millennium, I believe that we now have the modeling capability to tackle the complex problems in water resources planning and management (Wurbs, 1998; Singh, 1995). Kuijpers (1993) believes that the gap between integration at a strategic level and at the operational level is still very large. He goes on to argue that IWRMS approach cannot be achieved and implemented in a fragmented institutional set up, which includes several largely autonomous and poor coordinated administrative bodies. To quote Duda and El-Ashry (2000) "The failure to achieve integrated water resources management has been attributed to the strength of sectoral ministries in opposing the concept, as well as institutional bottlenecks occurring in implementation". He goes on to state that the availability of funding to "fix" problems caused by fragmentation and inter organizational rivalries keeps conflicts at bay. According to Mosely (1998) the core hindrance to integrated information management and thus water resources planning and management is the involvement of several often, uncoordinated organizations in the water sector. This is true in most developing countries. In the South African situation and therefore in most developing countries, the lack of human resources, rugged individualism with the spirit of pioneering and protectionism through data pricing by the state and parastatals are crucial barriers to the coordination of water resources planning and management activities (Maaren and Dent, 1995).

Therefore, the need for the creation of an institutional framework that will coordinate water resources planning and management responsibilities and activities at all levels of government is imperative for the success of conventional and IWRPM. The challenges of integrated land, water and ecosystem management on a basin scale can only be met by management at the lowest possible levels (Duda and El-Ashry, 2000). To quote Duda and El-Ashry (2000) "Interministerial collaboration at the national level in terms of a standing inter-ministerial committee for integrated management represents the first step forward. There must also be created the sub-national, basin-specific inter-ministerial committees to ensure that sectoral ministeries collaborate among sub-national political jurisdictions for basin wide water resources planning and management". IWRPM is being applied successfully to the Murray-Darling basin in Australia through the Murray-Darling Basin Commission. An example of IWRPM in the region is the Zambezi River Action Plan (ZACPRO 6 PHASE II) and is directed at developing an integrated water resources management strategy for the Zambezi river Basin. This project is being implemented and coordinated by the Zambezi River Authority and the SADC Water Sector Coordination Unit (WSCU). The establishment of the Zambezi River Commission will oversee all the activities of ZACPRO 6.

5. Summary and conclusions

Conventional and IWRPM approaches have been presented. Multi-sectorial is the principle approach in the conventional water resources planning and management. IWRPM is the incorporation of the socio human factors (stakeholder participation), economic issues and the ecological system. Therefore, it has been established that, if both approaches are well implemented in theory could attain same results.

However, conventional water resources planning and management has failed to lead to sustainable water resources development especially in developing countries where environmental preservation has received less attention to communities who have to deal with the immediate realities of poverty. Stakeholder participation, which is the key factor in IWRPM is also not possible in developing countries.

Both approaches have failed to accomplish sustainable water resources development. The major factors that have led to the failure of both approaches are: fragmented institutional set up, institutional bottlenecks occurring in implementation, lack of human resources, sectoral ministries opposing the concept, poor coordinated administrative bodies and/or organizations in the water sector etc. The major missing link in both approaches is administrative integration (institutional framework), that coordinates water resources planning and management responsibilities and activities at all levels of government. This missing link has also been recognized by Global Water Partnership and has been included in the GWP IWRM Toolbox and in the Murray-Darling and Mekong river basin systems (Malano et al., 1999). The establishment of an institutional framework which, will coordinate all activities, is very vital for the success of Conventional and/or IWRPM.

References

Ashton, P., Braune, E., Maaren, H., McKenzie, R.S., Orpen, W.R.G., Pitman, W., Rooseboom, A., Schulze R.E., Van Rooyen P.G., Van Vuuren S.J., 1998. Hydrological science in Southern Africa. Progress Report: 1995–1998 to the International Association of Hydrological Sciences.

Balackmore, D., 1995. Murray–Darling Commission. A case study in integrated catchment management. Water Scientific Technology 32 (5–6), 15–25.

Dantzing, G.B., 1963. Linear Programming and Extension. Princeton University Press, Princeton, NJ, USA.

Duda, A.M., El-Ashry, M.T., 2000. Addressing the global water and environment crisis through integrated approaches to the management of land, water and ecological resources. Water International 25 (1), 115–126.

DWAF, 1998. Water law review process. The philosophy and practice of Integrated catchment management: implications of water resources management in South Africa. WRC Report No. TT81/96. Pretoria, South Africa.

Falkenmark, 1986. Macro-scale water supply/demand comparisons on the GlobalScene—a hydrological approach. Beitrag zur Hydrologie 6, 15–40.

Falkenmark, M., 1993. Landscape as life-support providers: water related limitations. In: Graham-Smith, F. (Ed.), Population The Complex Reality: Population Summit of the World's Scientific Academies. Lund, New Delhi (The Royal Society, UK).

Frago, A.G., 1998. EU experiences with management of shared river basins: The management of shared river basins. The report of the Maseru conference. Ministry of Foreign Affairs. Delft, The Netherlands.

Grigg, N.S., 1996. Water Resources Management: Planning, Regulations and Cases. McGraw-Hill, New York, USA.

Hall, W.A., Dracup, J.A., 1970. Water Resources System Engineering. McGraw-Hill, New York.

Heathcote, I.W., 1998. Integrated Watershed Management: Principles and Practice. John Wiley, New York, USA.

High Performance Systems, 1992. Stella II: An Introduction to Systems Thinking. High Performance Systems Inc., Nahoser NH, USA.

Hillier, F.S., Lieberman, G.J., 1990. Introduction to Operations Research. McGraw-Hill, New York, USA.

Howe, C., White, S., 1999. Integrated resource planning for water and wastewater: Sydney case studies. Water International 24 (3).

Kindler, J., 1992. Water—The environmental and developmental dimensions—striking a balance. In: International Conference on Water and the Environment: Development Issue for the 21st century, Dublin, Ireland.

Kuijpers, C.B.F., 1993. Integrated water management in the Netherlands: Myth or practice. In: Biswas, A.K., Jellali, M., Stout, G. (Eds.), Water for Sustainable Development in the 21st Century Water Management Series, vol. 1. Oxford University Press.

Loucks, D.P., Tedinger, J.R., Haith, D.A., 1981. Water Resources Systems Planning and Analysis. Prentice-Hall, Englewood Cliffs, NJ, USA.

Loucks, D.P., 2000. Sustainable water resources management. Water International 25 (1), 1–10.

Lyneis, J., Kimberly, R., Todd, S., 1994. Professional dynamo: Simulation software to facilitate management and learning. In: Morecroft, J., Sterman, J. (Eds.), Modelling for Learning Organizations. Pegaus Communications, Waltham, MA, USA.

Maaren, H., Dent, M., 1995. Broadening participation in integrated catchment management for sustainable development. Water Science Technology 32 (5–6), 161–167.

Malano, H.M., Bryant, M.J., Turral, H.N., 1999. Management of water resources: Can Australian experiences be transferred to Vietnam. Water International 24 (4), 307–315.

Mitchell, B., 1987. A comprehensive-integrated approach for water and land management. Occasional paper #1. University of New England, Armidale, Australia.

Mitchell, B., Hollick, M., 1993. Integrated catchment management in Western Australia: Transition from concept to implementation. Environmental Management 17 (6), 735–743.

Mosely, M.P., 1998. Integrated information management for water resources assessments. In: Zebidi, H. (Ed.), Water: A looming Crisis? Proceedings of the International Conference on Water Resources at the Beginning of the 21st Century. IHP (UNESCO), Paris, France.

Postel, J.C., Lundin, C.G. (Eds.), 1996. Guidelines for Integrated Coastal Zone Management Environmentally Sustainable Development Studies Monograph Series, vol. 9. The International Bank for Reconstruction and Development/The World Bank, Washington, DC, USA.

Powersim Corporation, 1996. Powersim 2.5. Reference Manual. Powersim Corporation, Inc., Herndon, VA, USA.

Savenije, H., Van der Zaag, P., 1998. The management of shared River Basins. In: Background Paper to the Maseru Conference. Department of Foreign Affairs, Delft Netherlands.

SCOWAR, 1998. Water resources research. Trends and needs in 1997. Journal of Hydrological Sciences 43 (1).

Simonovic, S.P., 2000. A shared vision for management of water resources. Water International 25 (1), 76–88.

Singh, U.P. (Ed.), 1995. Computer models of watershed hydrology. Water resources publications. Littleton, Colorado.

United Nations, 1992. Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources: Agenda 21. In: United Nations Conference on Environment and Development. Rio de Janeiro, Brazil (Chapter 18).

USA National Water Committee, 1966. Alternatives in water management. Publication 1408, National academy of Sciences, National Research Council, Washington DC.

Ventura Systems, 1995. Vensim user's Guide. Ventura Systems, Inc., Belmont, MA, USA.

World Bank, 1993. Water resources management. A World Bank Policy paper. World bank. Washington, DC, USA.

Wurbs, R.A., 1998. Dissemination of generalized water resources models in the United States. Water International 23 (3).

Hu, X., 1999. Integrated catchment management in China. Water International 24 (3).