# op weg naar integraal waterbeheer

door prof. dr. ing. J.J. Bogardi

# OP WEG NAAR INTEGRAAL WATERBEHEER

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Inaugurele rede uitgesproken bij de aanvaarding van het ambt van gewoon hoogleraar in de hydraulica en algemene hydrologie aan de Landbouwuniversiteit te Wageningen op donderdag 18 januari 1990.

# OP WEG NAAR INTEGRAAL WATERBEHEER

*Mijnheer de rector, dames en heren,*

Al vanaf mijn eerste contacten met de Landbouwuniversiteit onderstrepen de rectoren in hun redes ter gelegenheid van academische plechtigheden de belangrijke rol van de internationalisering in het onderwijs en onderzoek aan de Landbouwuniversiteit. Inderdaad kan men mijn benoeming als hoogleraar in de hydraulica en algemene hydrologie beschouwen als een aspect van deze internationalisering.
Echter, internationalisering impliceert het gebruik van een internationale taal ten behoeve van de gezamenlijke communicatie. Om deze internationalisering een stuk te realiseren en om onze gasten uit het buitenland de mogelijkheid te geven mijn voordracht:

*'Op weg naar integraal waterbeheer'*

te kunnen volgen zal ik mijn inaugurele rede, getiteld: 'Towards integrated water resources management' in het Engels uitspreken.

However to retain a 'Dutch touch' I shall use the term 'integraal waterbeheer' instead of the more complicated and consequently less pronounced 'integrated water resources management'.
Using this Dutch expression by no means implies that the subject is only relevant in the Netherlands. Examples and nomenclature should not confuse the universal importance.

In a recent laudatio celebrating the 60th birthday of four distinguished water resources professors of the University of Karlsruhe, Daniel Vischer of the ETH Zürich has recalled cyclically changing eras of water resources engineering, periods being

predominantly occupied with the solution of certain problems. He has identified the era of flood control and river training, navigation, hydropower, environmental concern with major development in wastewater treatment etc., and concluded that at present no specific era could be defined. This concept of eras may simplify the real process of scientific and technical development, however it also helps to focus on the main issue(s) of a certain time.
I want to challenge his brilliant account on its conclusion, since I do believe that we are experiencing the emergence of a new era.
This new era distinguishes itself from the preceding ones mainly in two aspects

- it is not predominantly concerned with adding new physical elements to water resources systems,
- it is characterized by a new approach in tackling the problems encountered in water resources management.

In this new era special attention will be given to operational aspects of water resources systems yet to be built or already accomplished in the previous 'eras', while attempting to overcome sectoral thinking in resource management which characterized (and hampered) previous developments.
I am certainly not alone in realizing the tendency toward a new thinking. As far as national administrations are concerned the Netherlands is one of the first countries where not only the need for a change of attitude in the water resources development and management has been realized but in a series of policy statements, like the report 'Omgaan met water' (Living with Water) (1985) and the very recent Derde

Nota Waterhuishouding 'Water voor nu en later' (3rd report on Water Management/Water for the Present and the Future) (1989), the commitment to this change of approach has been specified. These policy papers call for the application of the concept of integraal waterbeheer based on systems analytical definition of the water resources management problems. Besides giving broad policy guidelines over almost 300 pages, the report 'Water for the Present and the Future' (1989) defines the term 'Integraal Waterbeheer' as follows: 'Interrelated water resources policy making and management by government agencies responsible for the strategical and management tasks, executed on the basis of the systems concept under consideration of the internal functional relationships between quality and quantity aspects of both surface – and ground–water, as well as the external interactions between the water resources management and other fields of management like environmental protection, regional planning, nature conservation etc.'
This sentence, which is translated from the Dutch original, does underline the change of philosophy in the management of water resources systems, without defining what actually has to be implemented, and how the particular agency should proceed to qualify its approach as 'integraal waterbeheer'. Thus, when I herald the dawn of the new era of 'integraal water–beheer', I do so by admitting modestly that there is neither much experience to characterize how integraal waterbeheer works, nor is it easy to define the term itself.

One possible visualization is provided by Stockman and van Stokkum (1989) (fig. 1), depicting integraal waterbeheer as the joint consideration of the

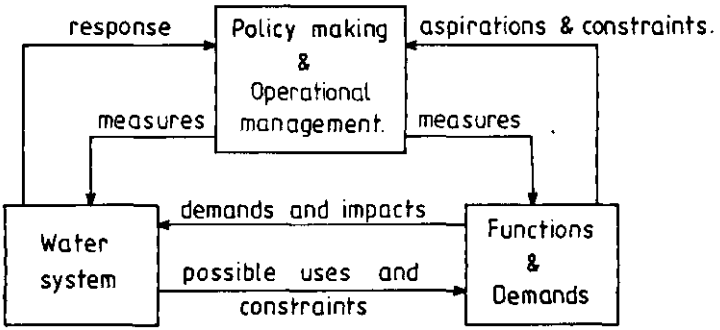


Fig. 1
Concept of integraal waterbeheer.
Source: Stokman G.N.M, van Stokkum H.T.S. (1989)

(physical) water system, the (societal) functions of and demands for water, as well as policy making and management. This scheme and similar ones, however, do not specify the mechanism, institutional imbedding, and depth of the integrated approach. Obviously beyond the acknowledged need for integraal waterbeheer there is still uncertainly about its scope, administrative mechanism, and techniques to be used. Thus, no wonder that the first report of the Workgroup 'Integraal Waterbeheer' of the TU Delft (1989) concludes that it is not possible to give a strict definition. Integraal waterbeheer can rather be described by its attributes, by the way it works, or better, by the way we expect it to work.

The dilemma of a speaker can not be greater!
I announce that we are heading towards an era of special thinking to deal with water resources

problems, and in the meantime I have to acknowledge our inability to provide a universally acceptable definition of it. Even if we accept that 'integraal waterbeheer' can not be defined exactly, its name still raises many disturbing questions.

It is of utmost importance to come at least to a common understanding over the term 'water resources management' (waterbeheer). Being at an agricultural university, I may use the analogy of an onion to visualize it. Like the bulb, the water resources management activity itself is usually not very much visible. It does however accumulate and amalgamate the essence of the concentric layers and sprouting the result, the stem, and leaves (fig. 2) to be seen and perceived. Thus, the integration is done by the plant. Therefore, the product should be judged whether it qualifies according to certain criteria and not its inputs.
The section of the simplified 'onion of water resources management' (fig. 3) displays the similarity I have claimed. To characterize water resources management the following aspects are worth to be noted:

First, that waterbeheer (water resources management) itself is an integration of technics, natural an social sciences, as well as economics imbedded in the political and administrative setup rooted in social aspirations, climatic changes etc. Second, that waterbeheer is basically a complicated decision making procedure, where we realize the consequence of these decisions rather than perceiving the process itself.
In this sense waterbeheer summarizes all the well

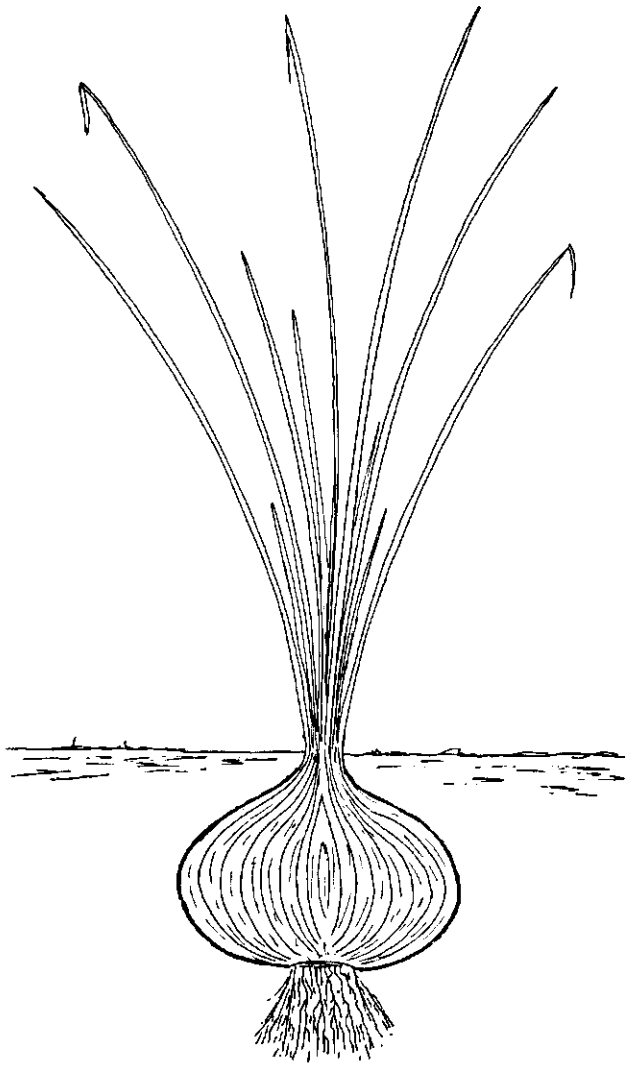

Fig. 2
Onion (Allium Cepa).

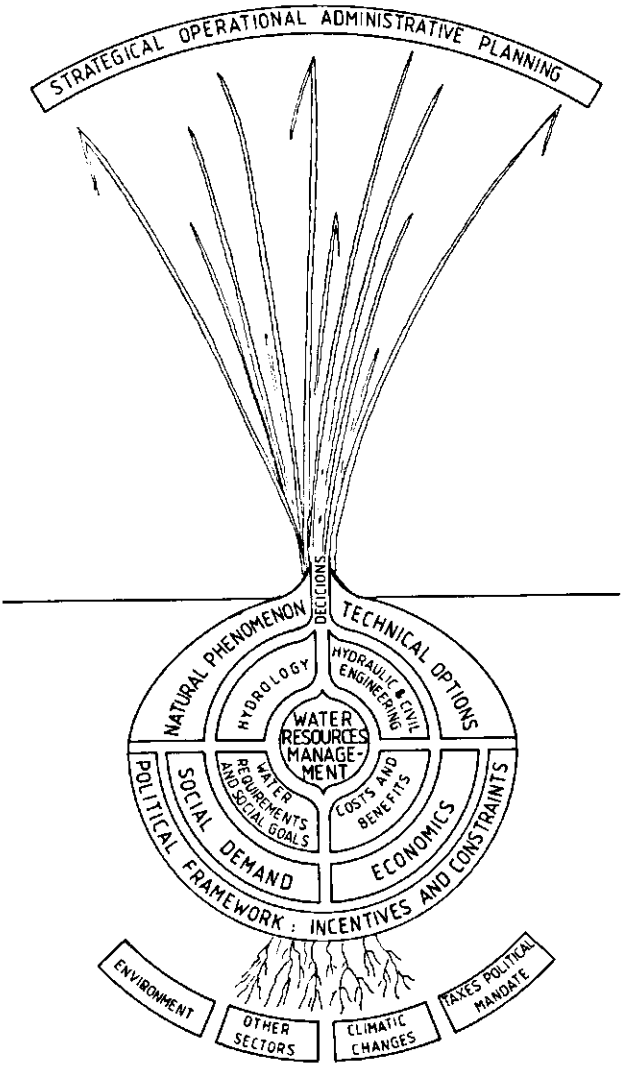


**Fig. 3**
**The onion analogy of water resources management.**

known activities of the preparatory phase (inception and planning), as well as that of the implementation phase (design, construction and operation) of a water resources system.
Why should then the term 'integraal' be added? The adjective 'intgeraal' creates the aura of high aspirations, promises distinctly new approaches vis-à-vis the previous practive and ultimately raising the expectation of 'better' decisions, and a more careful use of the resource water.
Both in linguistic and mathematical sense the word 'integraal' suggests completeness. Like integrating along an axis or over a plane, integraal waterbeheer can be imagined as an integration of water resources management considerations and efforts in space, time, over social implications, and sectoral water uses etc. (fig. 4).

Since the consideration of integration along one single axis would already warrant the use of this adjective, the proliferation of the attribute 'in-tegraal' could hardly be stopped even for small scale specific water resources plans, thus adding to the confusion lingering around the definition of integraal waterbeheer.
Limiting the extent of an 'integraal' approach along one single 'axis' can already be troublesome. Given that the earth has in fact only one hydrologic cycle, any compromise of the global scale consideration implies a certain loss of integrity. By accepting the imperative of practicality, the spatial extent of integraal waterbeheer may be limited to river basins or/and aquifer formations, rather than following administrative and political borders to define the scale of spatial integration. Needless to say that in

reality the use of administrative boundaries is still more common than that of physical ones.

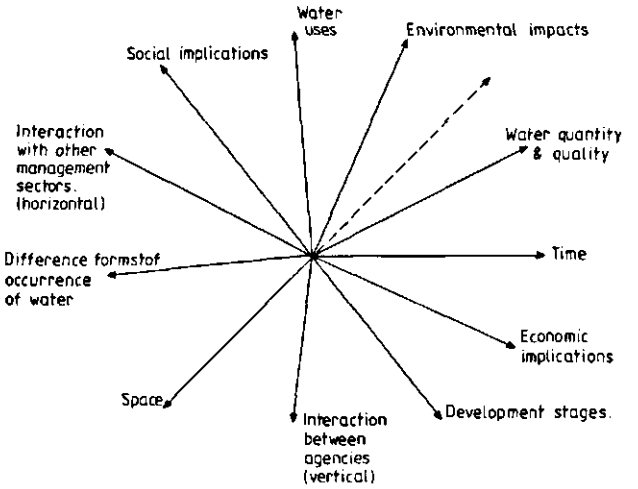


Fig. 4
**Possible axes to be considered in integraal waterbeheer.**

**The spatial constraints of integraal waterbeer should not confuse the fact that global interrelationships can not be severed simply by focusing on a particular area. Every single tree logged in the tropical rain forests, every ice block which melts away from the polar icepack has a certain impact on what we may face here as the challenge of integraal waterbeheer in the coming decades.**

In the light of these considerations, it seems contradictory to add the attribute 'integraal' e.g. to a ground water management plan on provincial scale, where only a segment of the hydrological cycle is of concern, considering may be only a part of an aquifer extending well beyond provincial boundaries. By the same token, the use of the term 'integraal' on national scale can also be questioned.

Consequently, the justification to call our water-beheer 'integraal' can not be sought alone in extending the problem to be studied along one or more of the axes of possible integrations. Rather, integraal waterbeheer should be identified from the outcome side, the very same way as an onion is appreciated in a market place.
From this end, integraal waterbeheer implies that the decisions concluded have been achieved by systematically incorporating the conflicting aspirations of different decision makers, along with the presence of competing agencies, institutions, and representatives of the public concern in the process.
This interpretation would enable to approach even a local problem within the framework of integraal waterbeheer. This classification is in fact a further specification of the definition given by the 'Derde Nota Waterhuishouding' (1989), by explicitly insisting on the use of a certain type of decision making setup to qualify as integraal waterbeheer.

The attraction of the name 'integraal waterbeheer' became too strong in the meantime to expect that my present lecture would be sufficient to derive a universally acceptable nomenclature. Thus, I just suggest a temporary truce over my thesis. I simply

want to formulate a couple of questions related to the introduction and wide scale use of integraal waterbeheer, as well as the implication of it on university education in general and on the basic scientific disciplines hydrology and hydraulics in particular. Ultimately the question to be answered is whether we are really moving towards 'integraal waterbeheer'.

*Do we have the necessary administrative setup?*

As the onion–analogy of fig. 2 reveals, integraal waterbeheer is imbedded in the political and socio–economic setup. Consequently, water management activities are doomed to fail unless they take explicitly into consideration the societal forces in action. With respect to integraal waterbeheer, it requires a formal framework within which the group decision processes, the negotiations over objectives, trade offs, aspiration levels, and technical options can be implemented. Nothing can show more explicitly the difference between the concept of integraal waterbeheer and the conventional approach than the comparison of the respective planning setups.

Fig. 5 and fig. 6 may not be unique representations of the planning process, but they are speaking for themselves. One basic difference is indicated by the incorporation of many more interactions in the framework for integraal waterbeheer than in the traditional setup. Moreover, the different problem perceptions of the various interest groups are explicitly considered.
Compared to the conventional administrative/tech–nical approach of fig. 5 the setup of the integraal

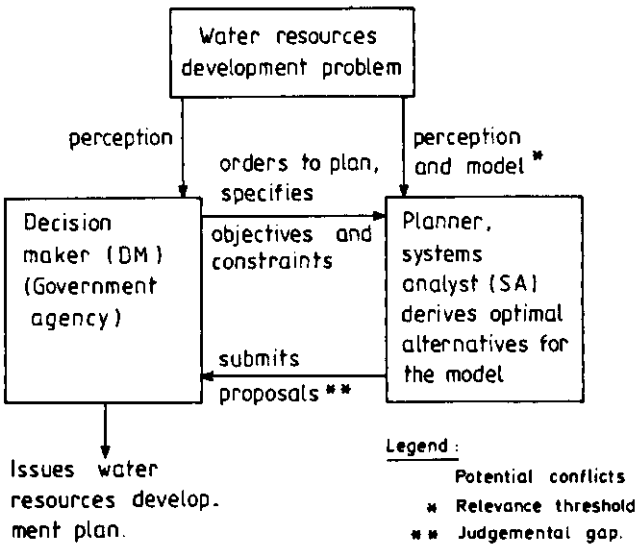


Fig. 5
Simplified Flowchart of the Conventional Planning Setup.

waterbeheer requires a (more or less) permanent presence of a – what may be called – executive water resources management agency (EWREMA) since planning is carried out in close relation to the other activities of water resources management, management activities of other agencies referring to the same area, as well as in interaction with the representatives of local interests and the responsible administration.
Essentially, integraal waterbeheer relies on the existence of water boards, river valley authorities and the likes with the necessary

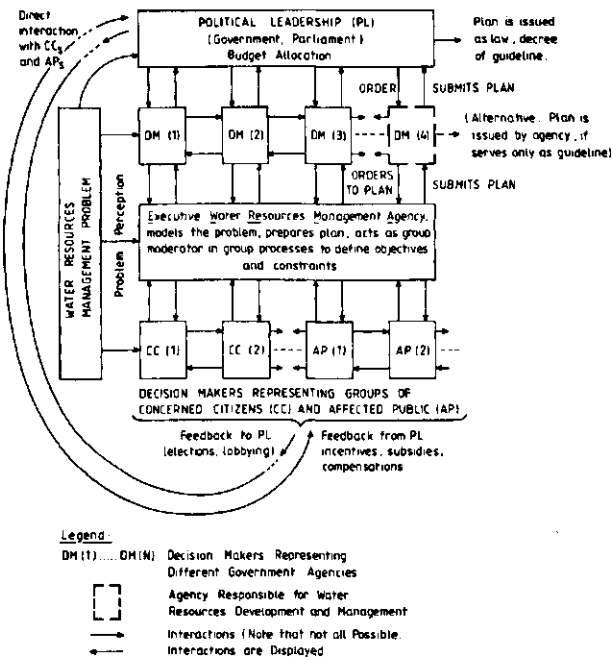


Fig. 6
**Flowchart of the planning setup within the framework of integraal waterbeheer.**

technical/administrative capabilities, as well as with close relations to the other parties involved. An EWREMA can be conceived as part of the government's administrative hierarchy, or as the professional arm of a co-operative type, self-

government organization of all the interested parties involved. Fig. 6 depicts the general situation, independent of the spatial scale of the problem, or whether the provincial or national government, or even the European Community represents the political setup. It is to be noted that through the system of water boards (waterschappen, zuiveringsschappen, hoogheemraadschappen) the Netherlands, along with few other countries, has the basic administrative/ technical infrastructure needed to implement integraal waterbeheer. The river basin (or area of concern) of a water board may be identified as the smallest scale for the strategical planning and as probably the ideal scale for operational management. The requirements of integraal waterbeheer, however, may imply eventual changes in the scope of existing water boards here and abroad to accommodate both water quantity and quality aspects, as well as to be entrusted with the management of surface and groundwater resources of their territory. There is even the need for international water boards (or river commissions) to cope with larger scale problems. Independant of its legal basis and administrative structures, it is definitely a must that EWREMA's are accepted as honest brokers by all the parties involved. Fig. 6 indicates the delicately woven interrelationships concentrating on the executive water resources management agency. This central role implies the potential problem inherent in splitting responsibility for integraal waterbeheer among several agencies at the same hierarchical level.

It is obvious that the need for the intimate knowledge of the hydrological, hydraulic, ecological, and other water and planning related problems, as

well as the manageable size of a decision making group, imply a certain scale limit for this outlined intensive integraal waterbeheer. Consequently, the need for a hierarchical management, following more or less the different political decision making and public administration levels, can be conceived. Obviously, the type of decisions and their technical detail must change from broad policy issues through supervisory and coordinating tasks to the 'real' integraal waterbeheer combining strategical and operational tasks at the lowest level of the hierarchy.
It is interesting to note that along with the accumulated experience, the planning structure in the Netherlands is clearly evolving in this direction as shown by fig. 7.

| Level of government | Quality of surface water | Quantity of surface water | Ground–water [1] |
|---|---|---|---|
| National | Indicative multi–year programme | Policy document on water management | |
| | Water quality management plan | Water quantity management plan | |
| Provincial | Policy document on water management | | |
| | Water quality management plan | Water quantity management plan | Ground–water management plan |
| Water–board | Water quality management plan | Water quantity management plan | |

| Level of government | Quality of surface water | Quantity of surface water | Ground–water [1] |
|---|---|---|---|
| National | Policy document on water management | | |
| | Management plan | | |
| Provincial | Policy document on water management | | |
| Provincial and water–board | Management plan | | Ground–water management plan |

Fig. 7
Proposed planning structure for water resources in the Netherlands.
[1]) Includes quantity of groundwater and quality as far as influenced by infiltration and groundwater flows. Other quality aspects are covered by the soil protection acts.
Source: Visée, Pennekamp and Koudstaal, in Koudstaal et al. 1988.

**The hierarchical structuring, as well as the wide application of the principles of integraal water-beheer, would facilitate its interaction with the strategic and operational tasks of the regional, land use planning, and environmental protection sectors.**

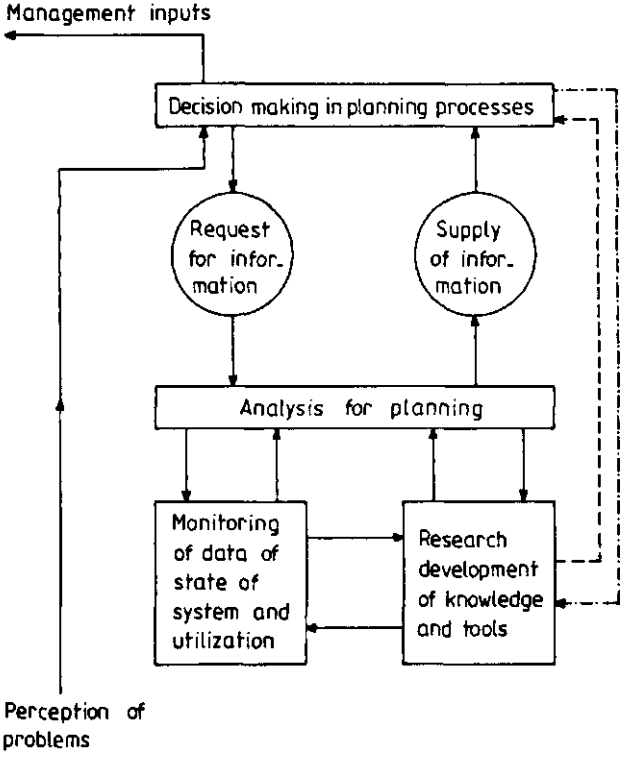


Fig. 8
**Relation between water resources management plans and plans of related policy fields.**
Source: Visée, Pennekamp and Koudstaal, in Koudstaal et al. 1988.

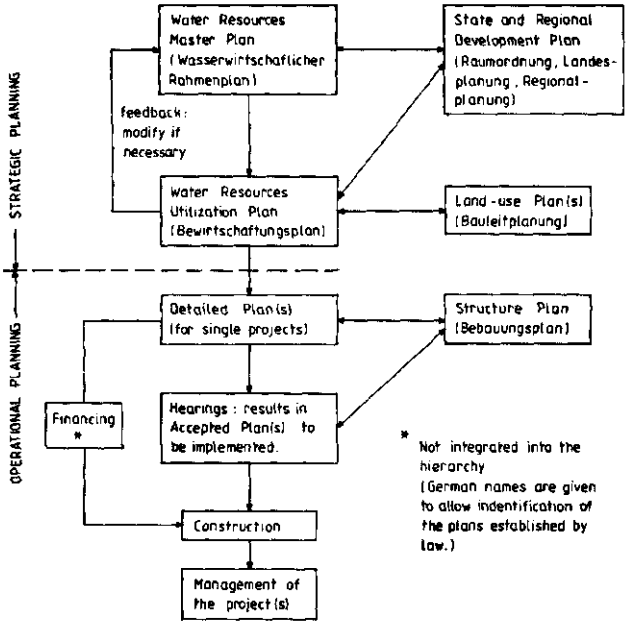


Fig. 9
Interaction and Hierarchy of Water Resources and Regional Planning.
Source: Bogardi et al. 1984.

Figs. 8 and 9 give examples for the Netherlands and the Federal Republic of Germany respectively. Beyond documenting the development in the last couple of years, the comparison of figs. 8 and 9 clearly underlines the pivotal role of the water board level where the integration of other sectoral (environmental, land use etc.) objectives can be incorporated in the direct operational integraal waterbeheer.

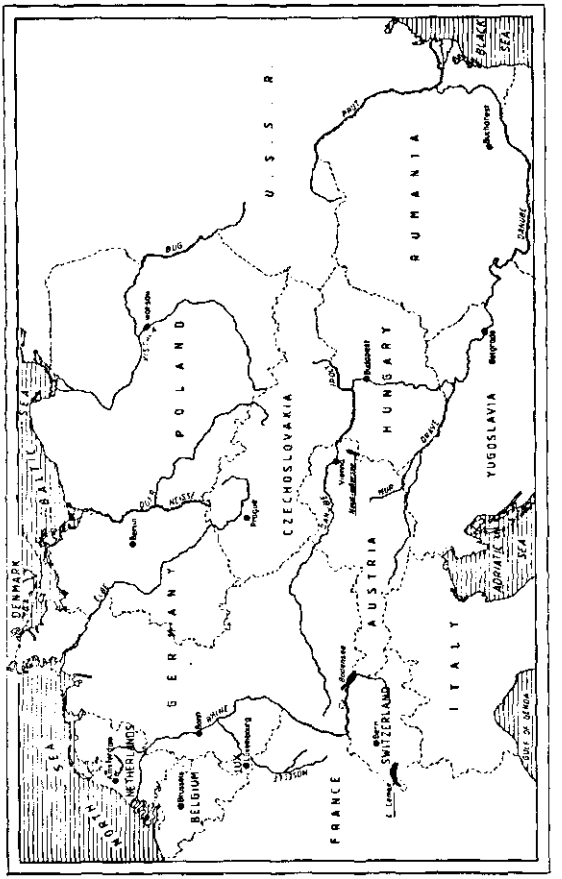


Fig. 10
Coincidence of major rivers and national borders in Central Europe.

Fig. 10 finally indicates the importance of international cooperation in integraal waterbeheer of (large) rivers. The present borders in Central Europe were drawn by keeping military and short sighted

political objectives in mind, thus using rivers to seperate rather than to unit people. We must realize the substantial dependence of the ultimate success of water resources management on a harmonious international cooperation.
In the eve of the European integration it may not be a frivolous suggestion to entrust existing international river commissions with more and more aspects of integraal waterbeheer.

*Do we have the appropriate technical tools?*

Integraal waterbeheer calls for a comprehensive approach both at the initial and planning stage as well as during the operational phase of a water resources system. Consequently, the question is more than justified whether the available techniques and methods

- to assess the need for improvement,
- to solve the 'S problems', namely to SELECT, to SITE, to SIZE, to SEQUENCE and to SCHEDULE an 'optimal solution' of a given problem,
- to define what 'optimal solutions' are within multicriteria decision making involving multiple decision makers, and
- to estimate the impact of these decisions within the water resources system etc.

are adequate to serve also the purposes of integraal waterbeheer?
Fig. 11 depicts the main areas of demand for 'tools' in a most general sense.

By accepting fig. 6 to represent the procedure of integraal waterbeheer, reference can be made to the large number of interactions inherent in the process.

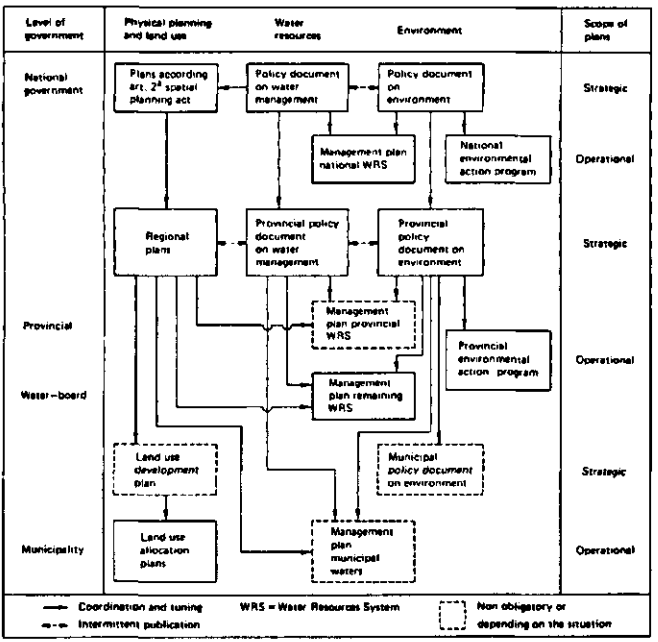


Fig. 11
Schematical representation of analysis for planning, research an monitoring in relation to integraal waterbeheer.
Source: R. Koudstaal and J. Wesseling in Koudstaal et al. (1988).

To account for changing objectives and aspiration levels in the course of decision making the assessment of needs, impacts, and implications has to be executed repeatedly, more or less in interaction between the decision making group and a (computer based) decision support system.
Given the required integration of water quantity and quality aspects, as well as that of the surface and groundwater together with the different uses and functions of the water, it becomes obvious that the available, mainly 'sectoral' or 'semi-integrated' techniques like rainfall-runoff models, water quality models, unsteady flow simulations, groundwater flow models, irrigation water demand assessment, and optimization of reservoir operation etc. are only partially applicable withing the framework of integraal waterbeheer.
The dilemma is twofold:

- -The techniques and models used in integraal waterbeheer should be more and more complex to reflect adequately the integration needed and more and more refined to improve accuracy, while at the same time these integrated models should be as simple as possible in order to keep the development and programming effort, the computational time requirements, and costs low, to ensure transparency of the model structure without jeopardizing the quality of the results.
- -Alternatively, an agreement should be sought among the decision makers to settle for a piecewise assessment of phenomena within the water resources system, thus to solve a problem with more or less inadequate techniques.

Given these contradictory requirements, it is

apparent that the proliferation and wide scale application of powerful computers is a pre-requisite of integraal waterbeheer. Besides being deployed in the process of decision making itself, adequate hardware facilities are needed to develop new models or modify existing ones to fit the specific accuracy requirements of the different hierarchical levels of integraal waterbeheer.
In this context, the extension of fig. 11 is of special interest. In addition to the measurement, simulation, optimization techniques, and civil engineering know-how, the original figure of Koudstaal and Wesseling (Koudstaal et al. 1988) has been modified to indicate the need for particular methods to support the decision making process itself.
The multitude of techniques and concepts available to facilitate negotiation over multiple criteria decision problems have mainly been developed for business applications (Goicoechea et al. 1982). Integraal waterbeheer implies, well beyond the similarities to business decisions, the consideration of the particular nature of the medium water, being simultaneously

- a commodity to be sold and consumed (drinking, cooling, irrigation water)
- a renewable, yet fragile natural resource to be protected and exploited (recreation, fishing, ecological function, nature preservation)
- a part of the national infrastructure to be developed and used (navigation, energy generation, conveyance of (treated) sewage and excess water)
- a source of catastrophes to be reckoned with and protected against (floods, droughts)
- a property to be taken into consideration (water rights) etc.

Besides the apparent need for integrated consideration of these attributes, the decision making in integraal waterbeheer is further hampered by perceptional differences of the decision makers (due to professional background), ranging from regarding water as the fluid $H_2O$ appearing in different forms throughout the hydrologic cycle to considering it alone for its scenic value as part of the landscape. Without going into great detail, the answer to the question whether we have the appropriate technical tools is rather NO than YES as far as ideal conditions for integraal waterbeheer are concerned. This diagnosis is not entirely unexpected, given that the institutionalization of the concept of integraal waterbeheer is quite new. It implies that intermediately integraal waterbeheer may rely on existing data sets and collection programs, as well as utilizing available simulation and optimization models. However, there is a great deal of effort needed to create date bases for calibration of simulation models conform with the requirements of integraal waterbeheer, as well as for efficient monitoring in the operational phase. Beyond improved measuring techniques, a careful choice of observed parameters with relevance to the subsequent simulation models is needed.
Simulation models provide the backbone for the assessment and impact analysis at various levels of integraal waterbeheer. As the consequence of this hierarchical structure (see fig. 8), at least three sets of simulation models are needed. Inappropriate matching of techniques and the accuracy requirement of the different decision levels would lead to waste of time and/or to false conclusions. As long as these requirements are not clarified, model choice will

remain the Achilles' heel of integraal waterbeheer. Due to practical limitations, data availability, time, and general availability of computer technology it is still improbable that simulation models with full fledged integration of uses, quality and quantity parameters, measures of reliability, occurrence forms (surface and groundwater etc.), and management options will be used in the foreseeable future.

As far as the decision aiding techniques are concerned, different models may be developed to fit the particular decision requirements of these management levels and to account for the varying composition of the decision making bodies. Obviously, the decision support models must be 'synchronized' with the accuracy of the imbedded simulation models. Among the various multiple criteria decision making techniques, the interactive, iterative, satisfactum generating type algorithms, Monarchi et al. (1983), Bogardi and Sutanto (1987), which leave the decision sovereignty with the group of decision makers involved, may have the best chance for practical acceptance at the operational level integraal waterbeheer.

The algorithmic development of both simulation and decision models would be enhanced by formulating a catalogue of requirements for the different management levels. Following the policy statements like 'Omgaan met water' (1985) and the 'Water voor nu en later' (1989), the next step could be the joint formulation of this catalogue by the state agencies, research institutions, water boards, and consulting companies.

The arrows of fig. 11 indicating the interaction between the development of tools and the acquisition

of knowledge regarding data monitoring and system state description, impact assessment, and decision support systems are going to be very relevant for the coming decade as far as the programs of research institutes and water resources related university departments are concerned.

*What are the implications of integraal waterbeheer for the university?*

Based on the analysis of the previous questions, it appears to be obvious that integraal waterbeheer is a formidable intellectual challenge for both the present and future generation of professionals. The answer to the last question indicated the wide scale need for further research and subsequent software development. Beyond the practical research need however, there is an essential implication of integraal waterbeheer upon the training of students. The problems we face may be summarized as follows:
Integraal waterbeheer is very much inter- and multidisciplinary in its nature, while fields of studies are still (usually) defined along established professional lines.
Training, especially engineering training, is technics oriented to respond to potential problems facing the future expert in his/her career.
Integraal waterbeheer, however, defines problems in a different way than done by conventional disciplines. It requires generalists to cope with the multifaceted integrated approach, yet university departments have traditionally been developed and manned by specialists.
Besides transferring knowledge, the most profound impact of a university upon its graduates is that it

forms his/her way of thinking. Consequently, the pre-requisite of the ultimate breakthrough of the idea of integraal waterbeheer is laying with the ability of the universities to ensure a smooth transition or new development of the curricula of related professions towards a program fitting the purpose of integraal waterbeheer. The formation of larger departments with increasing integrating potential, as well as interdepartmental working units with a mandate to shape both research and teaching are certainly the right step to achieve this goal. Universities with broad faculty roster and 'permeable' fields of studies are definitely in advantage over structures having engineering, natural science, agricultural, social science etc. faculties or similar clusters.

Being appointed to the chair of hydraulics and general hydrology of this university, it is most appropriate to review how these two fundamental disciplines may change to respond to the needs of integraal waterbeheer. As far as hydrology is concerned, I foresee the trend from the piecemeal approach of studying rainfall/runoff, low flow, floods, streamflow, interflow, groundwater, evapotranspiration phenomena etc. individually, to more comprehensive basin wide water balance studies. In this context, the emphasis from local towards larger scale problems will certainly be shifted. Hydrology, as the science of movement of water in the hydrocycle, will be redefined as scores of parameters have to be included for characterization of the water systems. Dissolved conservative material, organic micropollutants, nutrients, heavy metals, other toxic substances, as well as biological indicators are joining the traditional quality and quantity parameters,

like dissolved oxygen, biochemical oxygen demand, and discharge.
Modeling of hydrological processes will have to be done simultaneously to consider the propagation, storage, degradation or removal of other substances and indicators than water volume per timestep. In this context, event–based concepts will also gain in importance to characterize unfavorable coincidence of concentrations and discharge being detrimental or even fatal for the water system. Together with the consideration of the expected climate changes, the superposition of these events may form scenarios to be used in assessing water system performance.
Due to the pronounced operational characteristics of integraal waterbeheer, emphasis will have to be given to forecasting methods to support on–line management of the water systems. All these developments can not be imagined without the increasing reliance on 'modern' methods and technologies. The future training in hydrology can be characterized by a set of abbreviations. It will rely on SA (systems analysis), being increasingly PC (personal computer) based, using more and more RS (remote sensing) and GIS (geographical information systems) as input data to fulfill the requirements of the LS (large scale) approach of integraal waterbeheer.

In the case of hydraulics, some of the same abbre–viations can be considered. Joint dynamic modeling of quantity and quality aspects are to be considered for both short and long term simulation of hydraulic processes. Both hydraulics and hydrology will be taught by keeping very much in mind what it is for. This tendency may be characterized by adjectives. Recently, the term environmental hydraulics gained

wide spread acceptance. Following the 'battle cry' of environmentalist to renaturalize trained rivers the hydraulics of natural water courses with abundant vegetation became a concern of hydraulicians. This change of emphasis due to social pressure should remind us, that hydraulics is not simply the physics of fluids. The same river training which is now bedeviling many has been carried out to provide flood protection, navigable waterways, and an efficient drainage system.

Fig. 12
Swingbucket irrigation in Bangladesh.

Hydraulics and hydraulic design should be studied by keeping its social implications much more in mind than previously. The need for what may be dubbed 'social hydraulics' can be perceived by the example of the swingbucket irrigators in Bangladesh (fig. 12). This picture, which was taken in 1987, may remind us that there should, a hydraulically non optimal, yet socially acceptable solution be found somewhere between the swingbucket made out of a weed basket and, for example, the automatic tailwater controlled distributor type irrigation water supply system.
How fundamentally the social value structure can change within a few decades, or even years, has been seen on the example of river training.
Let us not forget that integraal waterbeheer derives its justification – among others – from the explicit considerations of these changing aspirations, objectives, and different criteria. Consequently, any student trained to work in water resources management must obtain sound basic knowledge of management techniques, economics, law, SA (systems analysis), etc. Particularly the abbreviations OR (operations research), S&S (sequencing and scheduling), as well as MCDM and MODM multiple criteria decision models, and multiobjective decision making are suitable to indicate these needs.
This review contains much more additions than omissions in comparison to the conventional curriculum. This is due to the conviction that integraal waterbeheer can not be developed without the profound knowledge of hydrology, hydraulics and other 'traditional' engineering disciplines.
This dilemma may be solved by creating either a special field of study 'integraal waterbeheer' at the undergraduate level or, as a more favorable approach,

to pursue the idea of a postgraduate study program – eventually within an interuniversity, or even European cooperation – to be conceived and managed by the respective working groups on 'integraal water-beheer'. This concept to link the training and research under the umbrella of interdepartmental and/or interuniversity working groups is based on the realization of the simultaneous need to develop methods to fit the specifications and demand for experts with the ability to think and act within the framework of integraal waterbeheer.

*Are we moving towards integraal waterbeheer?*

To answer this question we may summarize the previous replies. We found that there had been – at least in the Netherlands – a forward looking policy. A legal framework is being created to facilitate the introduction of integraal waterbeheer. Through the three management levels, and especially through the existence of water boards, there is an administrative infrastructure capable to adopt the principles of integraal waterbeheer.
Following the modified definition of integraal waterbeheer given in this lecture, changes in scope and responsibility may be advisable to proceed towards the 'ideal water board' structure, Togtema (1989).
As far as the methodological aspects are concerned, a quite considerable need for taylor-made simulation and decision support methods has been identified. Their development up to practical applicability will certainly take time. However, many models are available to fill the gap in the meantime. While not yet in full-fledged mode, an 'intermediate type'

integraal waterbeheer can already be reality.
Since the research community and university departments seem to be eager to respond to the challenge of this new approach, the optimism seems to be justified that we may be soon on track towards integraal waterbeheer.
This optimism of mine does not necessarily imply my belief that a steady phase of integraal waterbeheer will ever be reached. The experience of the conventional water resources management the time and spatial scale of water resources development acitivities, as well as the rapidly changing social preference structure warrant the caution to regard integraal waterbeheer as a dynamic process, to be modified as time passes on.
By embarking on this concept, engineering wisdom and scientific determination are challenged to keep following a road leading to an unattainable ideal.

Few days ago, the last decade of this century and millenium started. I can not imagine a more appropriate program for this decade than to crown the water resources management achievements of preceding generations with our attempt to strive towards integraal waterbeheer.

*Dames en heren leden van de benoemingscommissie, universiteitsraad en het college van bestuur,*

De leerstoel hydraulica en algemene hydrologie is na een meer dan vijf jaar durende vacature weer vervuld. In de advertentie werd er op gewezen dat de nieuwe hoogleraar ook op het gebied van het waterbeheer werkzaam zou moeten zijn.
Er wordt de bereidschap verwacht om een actieve

rol in de nieuw te vormen werkgroep 'integraal water-beheer' te vervullen. Deze wensen van de universiteit zijn ook mijn wensen. Ik heb de benoeming aanvaard in de verwachting dat de academische bescherming en de noodzakelijke middelen gewaarborgd zullen zijn om dit doel realiteit te laten worden. Ik dank u voor het in mij gestelde vertrouwen.

*Sehr geehrter, lieber Herr Prof. Plate,*

Es ist mir eine besondere Freude, Sie, meinen Doktorvater, aus dem Kreis meiner anwesenden früheren Vorgesetzten und Kollegen namentlich begrüßen zu können. Ich hoffe, und wünsche mir, daß Sie diese akademische Feier auch als die Ehrung Ihrer eigener Tätigkeit empfinden.

*Hooggeleerde Kraijenhoff van de Leur, beste Dirk,*

Je bent in 1958 met een afdeling Hydraulica begonnen. Dat is later de leerstoel hydraulica en algemene hydrologie en tenslotte de vakgroep Hydraulica en Afvoerhydrologie geworden.
Ik hoop, als je opvolger, dat het ons in de nieuwe vakgroep Hydrologie, Bodemnatuurkunde en Hydraulica eveneens zal lukken de door de technisch-wetenschappelijke ontwikkelingen opgelegde structurele, curriculaire en onderzoeksveranderingen bedachtzaam ten uitvoer te brengen.

*Hooggeleerde Feddes, beste Rainer,*

18 dagen geleden heb je het ambt van hoogleraar in de agrohydrologie en bodemnatuurkunde bij onze vakgroep aanvaard. Ik verwacht en hoop dat onze samenwerking

intensief zal zijn en impulsen zal opleveren voor onderwijs en onderzoek ten behoeve van integraal waterbeheer.

*Geachte dames en heren van de vakgroep Hydrologie, Bodemnatuurkunde en Hydraulica,*

Na de vele veranderingen, onzekerheden en fusies tijdens de laatste jaren hoop ik met u op een rustige tijd en produktieve samenwerking om het potentieel van onze vakgroep tot bloei te brengen. Door de vriendelijke atmosfeer binnen onze groep hebben wij aan de belangrijkste randvoorwaarde al voldaan.

*Dames en heren studenten,*

Uit mijn rede blijkt dat integraal waterbeheer wel een belangrijke taak voor u zal worden. Ik verwacht uw kritische opmerkingen op, maar ook uw enthousiasme voor, en professionele toewijding aan onze gemeenschappelijke weg naar integraal waterbeheer.

*Dames en heren, geachte aanwezigen* ik dank u voor uw aandacht.

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