Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 14 (1992)

Artikel: Creativity in changing delta Duch [i.e. Dutch] ecosystem management

Autor: Saeijs, Henk L.F.

DOI: https://doi.org/10.5169/seals-13908

Creativity in Changing Delta Duch Ecosystem Management

Gestion contrôlée de l'écosystème aux Pays-Bas

Ökologische Steuerung in den Niederlanden

Henk L.F. SAEIJS
Biologist
Ministry of Transport
& Public Works
Middelburg, The Netherlands

Henk Saeijs, born 1935, received his PhD in biology in 1982 at the University of Leiden, with the thesis 'Changing Estuaries'. For eleven years he was director of the Environmental Department of the Delta Project Organisation. For six years he was the driving force behind the modernisation of water management in his country. After two years of directorship at the Directorate North-Sea, he became responsible for the management of the complex, new, wet and dry infrastructure of the south-west part of the Netherlands.

SUMMARY

Experience gained this century with two very complex hydrological engineering projects in the Netherlands, resulted in a new so called 'integrated water-system management' approach, treating of symptoms developed, towards controlled ecosystem management, resulting in a new way of living with water. Examples illustrate what lessons can be learned; how new management concepts developed; and what applications are possible. The main message is to emphasize the positive role man can play in wetlands.

RÉSUMÉ

L'expérience acquise au cours de ce siècle, grâce a deux projets d'ingénierie hydraulique très complexes réalisés aux Pays-Bas, a débouché sur une approche de gestion de système intégrée. Le rapport présente les solutions apportées aux problèms rencontrés au cours de la mise en place de la gestion contrôlée de l'écosystème, qui a débouché sur une nouvelle manière de gérer l'eau. Il expose les enseignements qui ont pu être tirés, de nouvelles notions de gestion et les applications possibles. Le rapport met l'accent sur le rôle positif que l'homme peut jouer dans les zones humides et marécageuses.

ZUSAMMENFASSUNG

Die in diesem Jahrhundert in den Niederlanden bei zwei komplizierten Wasserbaugrossprojekten gesammelten Erfahrungen resultierten in einem grundlegend neuen Konzept, dem sog. integrierten Systemmanagement. Statt wie bisher gewissermaßen nur die Symptome zu behandeln, entwickelte man Verfahren zur Kontrolle der Gewässer als Ökosysteme, eine neue Art des Umgangs mit dem Wasser. An Beispielen wird gezeigt, welche Lektionen man gelernt hat, wie die neuen Konzepte entwickelt wurden und wie sie angewandt werden können Vor allem ist deutlich geworden, daß der Mensch in wasserreichen Gebieten eine positive Rolle spielen kann.

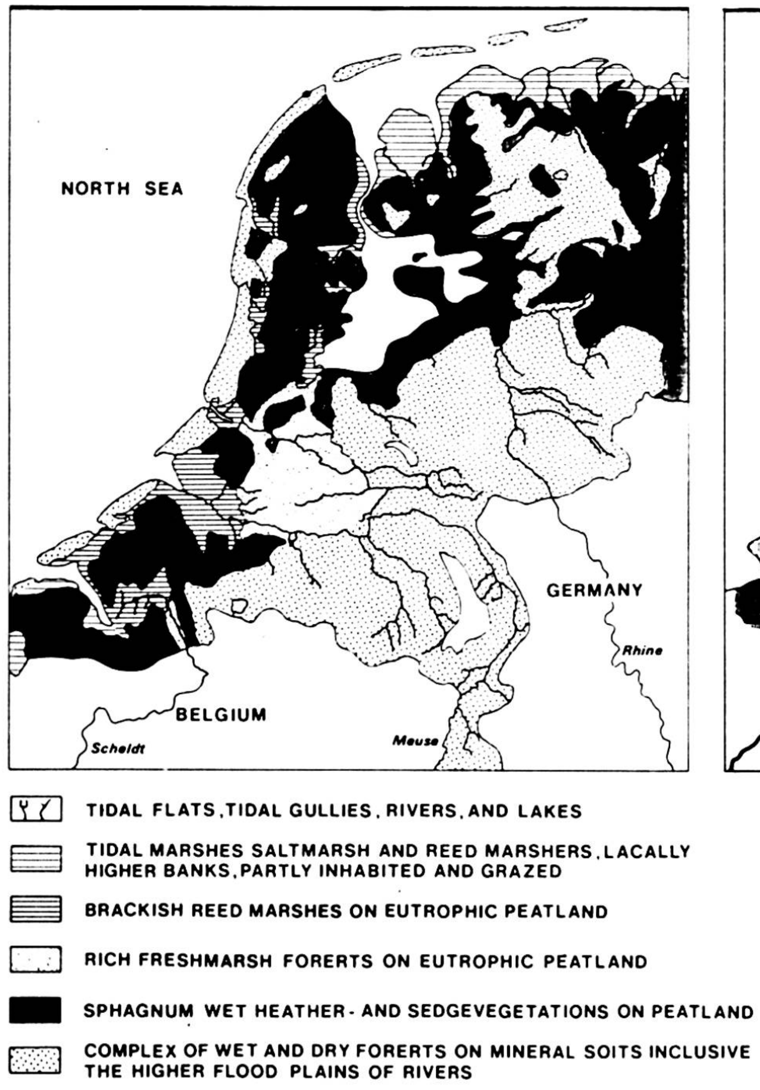
1. INTRODUCTION

The Dutch can be characterized by the expression 'God created man, but the Dutch created their own land'. Two thousand years of conditioning behavior became the 'art of a nation' [1]. In the twentieth century however hydraulic engineering threatens to become a curse instead of a blessing. In the last decennia spectacular developments took place, resulting in a new way of living with water. Coöperation instead of competition between technologists, economists and ecologists resulted in the new socalled 'integrated- watersystem-management' approach. Treating of symptoms developed towards controlled ecosystem management. With some examples is illustrated what lessons can be learned, from 2000 years of living with water, how new design and management concepts developed in the last decennia and what applications are possible.

2. LESSONS FROM 2000 YEARS OF TRIAL AND ERROR

2.1 From an ad hoc to a systematic approach

The Netherlands is situated at the end of four important European river systems, the Rhine, Meuse, Scheldt and Ems. So most of the Netherlands is actually a riverdelta, (fig.1). A part of the country (40%) is situated above sealevel. There it is too dry in summer and too wet in winter.



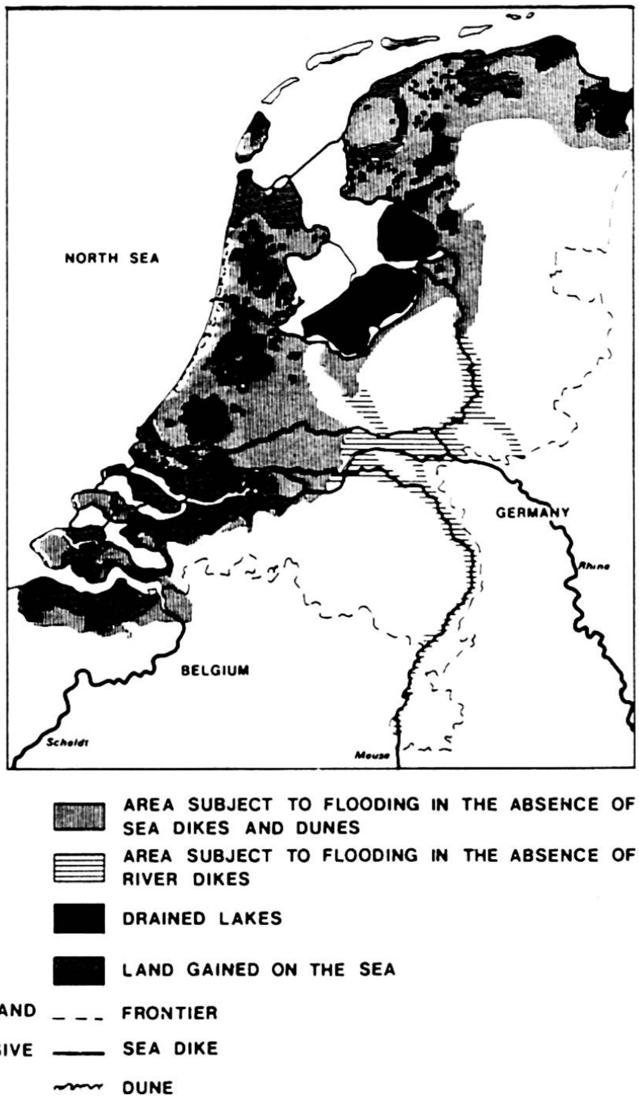


Fig. 1 A reconstruction of the ecological situation of the Netherlands in Roman times [5].

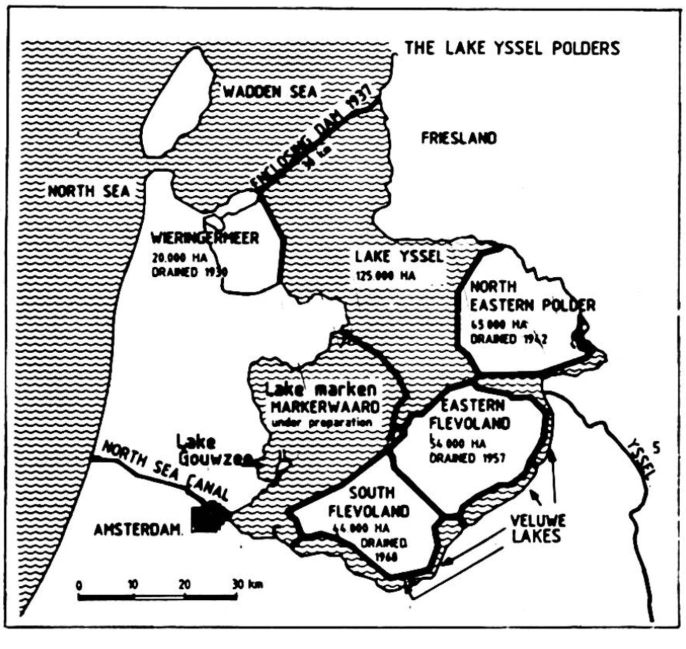
Fig.2 The Netherlands, 20th centu ry. The polders in down stream flat areas are made by draining lakes or by re claiming coastal embankments.

The major part of the nation however (60%), is situated below sealevel and exists as a result of human action and dedication (Fig.2). In the coarse of 2000 years, hydraulic engineering activities changed in character [2,3a,4]; from small-scale to large-scale; from defensive to offensive; from short-term to long-term; from specific to multifunctional; from conflict to harmony; and from stemming the tides to controlling them. Local coastal engineering measures, from the 1st-11th century; turned into well-organized dike building programmes, from the 12th century; into land-reclamation from inland lakes, from the 16th century; and into large-scale and complex transformations in the 20th century (Fig.2). A universal pattern developed, illustrating that wherever in the world authorities are dealing with water, sooner or later they will be confronted with the following coherent range: *The area* to be managed (river-basin, river, lake etc.); *the interests* associated with this area; *the potentials* of the ecosystems involved; *the machinery* necessary to ensure people's behavior (laws etc.) and to control the processes of the system (sluices, barrages, dams, pumps, models etc.); *the organization* responsible for functional management and *the financial means.*

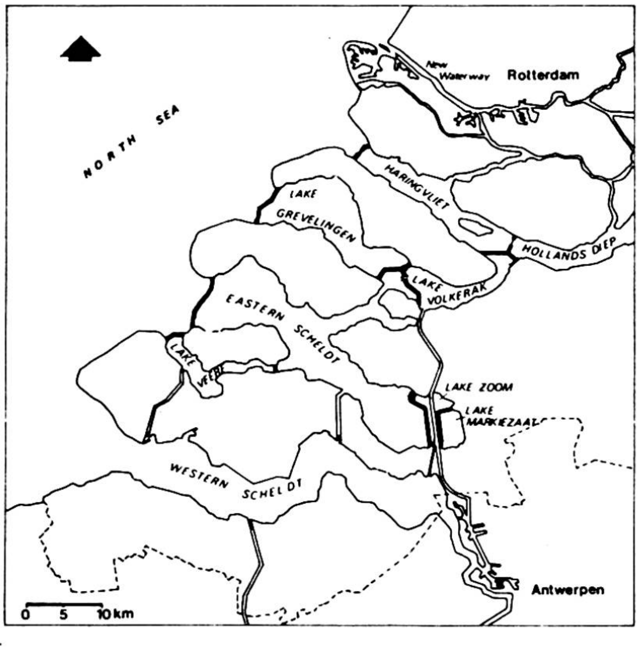
<u>2.2 'Divide et impera', compartmentalization.</u>

In the Netherlands, the twentieth century has been characterized by large-scale operations such as the Zuiderzee- [5,6]) and the Deltaproject [3b,7,8]. Action was necessary otherwise a large part of the country would have been eroded away.

The aims of the Zuiderzeeproject (5000 km2) were; safety, land-reclamation and storage- and control of freshwater. The project involved dividing the area up into thirteen sections or 'compartments', separated by dikes and dams; four polders and ine lakes (Fig.3). The aims of the Deltaproject (4000 km2) were; safety, storage- and control of freshwater and to combat salinization. Seven estuaries were divided up in twelve compartments, among which nowadays are salt-, and freshwater lakes and a tidal controlled estuary [9,10,11] (Fig.4).



<u>Fig.3</u> The location of the Zuiderzeeproject in the Netherlands. The stage of execution in 1989, with the compartments, segregated by dikes.



<u>Fig.4</u> The location of the Deltaregion of SW-Netherlands, with the compartments segregated by dikes. The figure refers to the situation as it is now after completion of the Deltaworks in 1987.

Compartmentalization (to divide an area in compartments, in one way or another, for example by dams, isolated from each other) meant, that the compartments could be developed in stages. By dividing the area into compartments, it has proved to be possible to control elementary forces of nature and to facilitate the choice of particular (different) types of environment. We are talking here of; *The strategy of 'divide et impera'.* If the differences in environment between the original tidal estuaries (Fig.1.), are contrasted with the current, chosen and developed, environments of the polders and fresh- and saltwater lakes (Fig.2), then it is clear that the process of creating a compartmentalized region, has set new ecological conditions, with changes in landscape and utilization of the region. A lesson is, that the ecological impact of compartmentalization, the following choices of type of environment and the institution and management of the new system, have important ecological, economical and social potentials!

2.3 'Waterreclamatiōn', an alternative for 'landreclamation'

Let us have a quick look at the Zuiderzeeproject. Although the main emphasis was originally on agriculture (Wieringermeer, 1930), this was soon broadened to include urbanization (Noord-Oostpolder, 1942) and recreation, landscape and nature conservation (Flevopolders, 1957 & 1968).
By the time that work was ready to start on the Flevopolders, ecology had begun to assume greater importance in construction, planning, management and decision making. As a result in the seventieth another significant change took place; the creation of new marshlands, instead of reclaiming them. After defining certain environmental conditions (waterlevel, residencetime, nutrients etc.), the new environment has effectively been left to nature. Management is limited to controlling important environmental boundary conditions and only intervenes, when developments evidently go in the wrong direction. By applying the same basic principle, with different conditions, it is possible to allow other types of environment to develop! The 'Markerwaard' (until now Lake Marken), would actually form the fifth polder. After reassessing whether to proceed with land reclamation work in Lake Marken it has been decided to choose for the watersystem. This represents a second significant change in traditional (Dutch) thinking; the conditioning of terrestrial systems is now no longer considered to have sole importance, just as fresh-watersystems are also being seen as valuable alternatives. This trend is actively being pursued in the Delta-area, but with the inclusion of additional new elements such as salt waters and controlled tidal systems. 'Landreclamation' developed into land- and..'water- reclamation'.

2.4 The purifying effect of a range

The fact that using the possibilities afforded by the aquatic infrastructure allows a new ecological perspective to be developed, is illustrated with the following example.
The river Yssel, which mainly contains water from the river Rhine, flows into Lake Ketel (Fig.3). The majority of the sediments it carries, which are contaminated with pollutants, settle in Lake Ketel. This accumulation of toxic sludge in the Ysseldelta has polluted the lakebed severely. However as a result, the quality of the water that flows on, into Lake Yssel, has undergone considerable improvement. Further improvements in quality are also occurring in Lake Yssel due to physical/ chemical/ biological processes, that are taking place. Since Lake Marken receives its water from Lake Yssel, in addition to supplies of rainwater, this lake derives substantial benefits from its location and relative position in the compartmentalization system. Lake Gouwzee is even more favorably placed in this respect. It is not surprising, that this was the first in this series of lakes, where abundant submerges vegetation was found again, after it had disappeared, as a result of eutrification. In these situations it is of course important that such 'gains' are not frustrated by local sources of pollution. Two interesting management strategies can be identified: *The strategy of concentrating problems in particular areas and the strategy of interconnected surface waters.* The first strategy is really an emergency measure. As long as upstream prevention cannot be guaranteed, the downstream distribution of pollutants can be considerably reduced, by regulating the flow of noxious substances. This strategy is translated now into operational options. Studies are going on to optimize the sediment-trapping function of lake Ketel and to isolate the contaminated sediments from the surrounding areas, the surface- and groundwater. An experimental project is in preparation.

2.5 Polluted beds a costly surprise

In 1867, The New Waterway, a shipping canal between Rotterdam and the Northsea became operational. Although it was in economical terms 'a lucky hit', in terms of hydrological engineering it was rash. As a result salt penetrates far up-country and the safety of the inland polders decreased. One of the arguments for the northern area of the delta project in this century was, to overcome these salination and safety problems. But by doing so tremendous new unforseen problems arose. In 1970 the most important outlet of the Rhine and Meuse, the Haringvliet (Fig.4), was closed off by a sluicecomplex [12]. An estuary was transformed into a freshwater river/ lakesystem. The results were disastrous. The life community died integrally and restoration is nearly impossible. Though an increase in sedimentation was expected as a result of the intervention, only in 1980 did it become clear, that the Netherlands became the rubbish belt of the Rhine, Meuse and Scheldt. More than 150 million m3 of highly polluted sludge have settled there until now. In the next 20 years the amount of polluted sediments will increase with 0.5 to 2.5 billion m3. The ultimate amount depends on the success of the upstream sanitation operations. The costs of a clean up operation (carefully calculated at 15 US $ /m3, stored in isolated and safe depots) are estimated now between 7.5 and 37.5 Billion US $! The alternative, 'to keep it where it is' appears to be even more dangerous and expensive, because many dangerous micro-pollutants, like pesticides and heavy metals, will spread over the area by infiltration, seepage and diffusion processes, with disastrous long term effects and an increase in the amount of polluted soil. As in the case of Lake Ketel and Lake Yssel there is a short term positive side effect. The North Sea is safeguarded against this pollution! The lessons to be learned from this experience are also of interest to other countries. It can be expected that if rivers upstream of a dam are being seriously polluted, then similar accumulation phenomena are likely to occur. The accumulation may develop more rapidly at one dam than at another, but the final result will be the same; lake- and riverbeds are practically lifeless and unable to carry out their essential functions in watersystems. Moreover polluted riverbeds also act as 'storage areas'. It is thought likely, that even if the original sources of pollution are removed, contaminated riverbeds will still act as emission sources over the coming decades. The closure of the Haringvliet has many more negative side effects [12]. It goes too far to discuss them here, but the impact of the project is so destructive, that authorities to day seriously consider to reintroduce tide, by using the Haringvliet sluice as storm 'surge-barrier' and 'tide reducer' and 'outlet', instead of outlet only as it is used now !

2.6 Protection by accident

The 'divide et impera strategy' was also applied in the case of the Deltaproject, but the arguments for doing so and the manner of implementation differed considerably [13]. The compartmentalization operation in the Zuiderzeeproject was basically motivated by opportunities for agriculture. However, in the Deltaproject hydraulic engineering considerations were instrumental (Fig.4). This has eventually resulted in a compartmentalized area characterized by many different types of environment [7]. The seven estuaries were transformed into either fresh-, brackish- or saltwater environments, boarded by dry fallen intertidal areas. One estuary was converted into an environment with reduced, but controllable tidal movements. As a positive result of compartmentation, the central area of the south-western part of the Dutch delta was in time protected against the pollution of the Rhine and Meuse, by the construction of the Volkerakdam and Volkeraksluice (1969), and of the Scheldt by the construction of the Kreekrakdam (1867) and Kreekraksluice (1965). This side effect was not planned. It was just luck, we realized later on. Now it is ready for application.

2.7 Converting an estuary to a salt lake

It is not possible to discuss all the details concerned. A list of references has therefore been appended [3,4]. However, one exception is made. Lake Grevelingen was formed when the Grevelingendam (1968) and the Brouwersdam (1971) were completed [14,15]. As a result the Grevelingen estuary has been transformed into a salt lake (17 g Cl^-/l), surrounded by extensive shallow areas which are now covered with vegetation (Fig.4). The lakebed is unpolluted. The water in the lake is clear; Secchi classification >10 m, even in summer. Primary production rates are relatively high and are still increasing. In spite of high concentrations of N and P, there are no eutrophication problems. The ecosystem in the lake has adapted to the new situation in a reasonably short period of time. The composition of the ecological communities present, is diverse and has now achieved an acceptable degree of stability. The lake is developing as a wetland with an international reputation. How did this happen and how was it brought about? In 1971 the Dutch people were faced with the consequences of the decision to close off the estuary. An active and healthy estuarine community was struggling for its survival, when the influence of the tides disappeared overnight. In the intertidal areas, that no longer remained under water, and in water where the depth exceeded 8 meters, all forms of life died out. Pessimistic predictions began to be made about what the future would hold. However I suggested, to 'create the most favorable new conditions possible, for a saltwater lake and let nature take its course'[3c]. The properties and processes of a saltwaterlake ecosystem were unknown, but by using approaches of 'best professional judgement' and 'adaptive environmental management', the final result is quite acceptable. Although much was left to nature, where necessary, measures were taken to control the situation. The main management actions concerned were control of the waterlevel, residence-time, salinity and stratification, added nutrients and living organisms from the sea. Consequently the link with the sea had to be restored. The sluice in the Brouwersdam must allow water to flow both out and...in. The original sluice was designed only as an outlet. The capacity and location had to be sufficient and adequate for waterlevel-, salinity- and oxygencontrol. It was essential, during the salination process, to ensure a large enough capacity to allow sufficient supplies of oxygen to be introduced into the hypolimnion. This was important since the salinization process had led to a very stable density-stratification. A further requirement for the sluice was to allow a free exchange of organisms with the sea. The developments taking place were studied and monitored carefully, using techniques such as simulation modelling. By doing this, it was possible to have a 'dialogue' with the system. This is called: *The strategy of spontaneous development within certain, man-induced and controlled, environmental conditions* [3c,7].

How has it been possible that, even though the eutrophication level is high, no eutrophication problems have occurred? It has become clear that nitrogen and not phosphate is the major growth limiter [16]. The high phosphate level is thus not important! After all, a large amount of nitrogen leaves the system in a gaseous form, as a result of denitrification processes. Filter feeders such as oysters (*Ostrea edulis*) and mussels (*Mytillus edulis*), together ca 80% of the biomass of the zoobenthos, play an important role in this process. They are filtering out large amounts of algae. From research [16] it appears, that they are filtering the water of lake Grevelingen roughly eight times a year. As a result there is a Nitrogen-turn-over-rate of ca. eight times a year. Bacteria are doing the rest. They convert nitrates to free nitrogen!
It appears that waterplants play another important role. Large stretches of the intertidal zones, that have become permanently submerged, were covered with seagrass (*Zostera marina*). Research has shown, that they secrete substances, which can check the growth of algae. Hypothetically speaking, the seagrass play a part in suppressing the excessive production of algae.
The lake and surrounding former intertidal plains have since 1990 the status of nature reserve on a European level! Moreover it is very attractive for recreational purposes and fisheries. All together good for a roughly estimated gross income of 50 million US $ each year. The main lessons of the new salt lake Grevelingen to be learned are summarized:

- The choice of a salt- rather than a freshwater lake represents another change in (Dutch) tradition. After all, salt in water is seen as a problem in agriculture:
- New saltwater environments offer wide potentials, if their development prospects are approached actively, both in economic and in ecologic denotation;
- By laying down environmental conditions and providing proper administrative guidance this process can be directed. After all, changes in the ecosystems lead to modifications also in the way they can be used. It is thus essential, that choices are made on time and that the decision-making process is speeded up;
- This approach had consequences for the design of hydraulic engineering works.

This approach allows the conditioning of the system as a 'policy and management objective' to be primarily considered in relation to the interests involved. This means that when changes occur, the transformation processes are given priority in policy and management. Experience has shown, that it is important to have a balanced administrative approach involving all the relevant authorities rather than, with a single authority i.e. the government alone [10].

2.8 Changing conditions, a challenge

The most important conclusion that can be derived from experience gained over the last century is, that the design and management of such engineering projects should not simply be directed to certain specific aims, such as safety or waterstorage or water distribution. They need full acknowledgement of the importance of the processes of change that take place in a landscape. Moreover it merits consideration to evaluate carefully former hydraulic engineering projects before starting new ones. Then the role of man in wetland management can be much more profitable. It is not only valid in coastal engineering projects, but also in other project, like weirs in riverbasins. Better than in the past, attempts must be made to harmonize interests and make proper use of the opportunities offered by, water, ecological knowledge, change and creative approaches to watersystems and aquatic infrastructure. *Strategies based on prevention and protection must evolve into more harmonious approaches based on cooperating with nature and dealing with watersystems.* A further differentiation of policy by area is a logical development in this context. The water managers have to develop into active and purposeful entrepreneurs.

3. FROM TREATING OF SYMPTOMS TOWARDS CONTROLLED ECOSYSTEM MANAGEMENT

3.1 Water only for human use?

The revolutionary developments that took place in the Netherlands over the last twenty years, are by no means over yet [4]. Let's have a quick look at the developments of the last three decennia! It might be very helpful to understand the mainframe: After World War II attention was focussed on reconstruction and economic expansion. In this context, in 1968 Dutch government put forward a first national water policy document [17]. Understandably the basic philosophy was, that the demand for water had to be met everywhere and always. The policy was related to the supply of domestic and industrial water, drainage, combating salinization and getting infrastructure necessary to attain this. Groundwater was regarded as the basic supply for drinking water. Water was only seen as a resource for human use! The transport function of water (shipping and pollution) was not mentioned. There was no cost/benefit analysis added. Water quality was defined in terms of 'unacceptably high levels of 'inorganic substances' (read: salt) and organic substances (read: oxygen consuming substances).

Salt water was even referred to as 'useless'(!) and 'poor quality'(!). The basis for the infrastructure was: 'the need for measures to prevent salinization and for combating salt from the river Rhine, water supplies in the Lake Yssel and a link between Lake Yssel and S.W.Netherlands'. 'New reservoirs should be constructed in the dunes and in the new Lake Grevelingen. These measures were estimated at 1.5 billion US $'.

3.2 Protection against pollution

In 1971 the Pollution of Surface Water Act passed the Parliament. The aim was the protection of the environment against pollution, because...the human use was at stake. The policy became operational in three Indicative Multiyear Plans for Water (IMP 1974, 1979, 1982). They have made an extremely important contribution to extending water quality policy. As a result the various water authorities were brought much closer together, which meant that they could learn from each other's experiences. The basic philosophy was the combat of water pollution, both in a preventive and a curative sense. In the first IMP [18] the problem was identified as being an excess of oxygen-consuming substances. The remedy suggested was to treat these substances like the discharge from sewerage systems. One water quality map showing the oxygen content in different areas was prepared as part of this report: The second IMP [19] also included the 'substances on the black and grey lists'. Emphasis was placed on defining the 'basic quality' of the water. The increased knowledge in relation to the purification of non oxygen-consuming substances is also reflected in this policy document. Four water quality maps were given, concerning; oxygen, phosphates, heavy metals and organic micro-pollutants: The relationship between water quality policy and environmental policy was more fully dealt with in the third IMP [20]. Function (use) oriented and ecological objectives were included for the first time. New problems were discussed, such as lake and riverbed pollution and non-point-source pollution: The realization has grown that surface waters are ecosystems, that is to say, where organisms as well as physical, chemical and biological processes have an important role to play: This new insight makes it possible to describe these relations in a more logical and coherent way. It was obvious that in further up-dating such policies, attention should be paid to not only broadening the approach, but also to integrating both quantity and quality of waterpolicies. Developing a stronger ecological basis for water management, policy was also seen as essential.

3.3 Integration of various aspects

In the second Policy Document on Water Management [21], an attempt was made to integrate the various aspects. The document was based on the results of a modelstudy 'Policy Analysis Watermanagement Netherlands' (PAWN) [22,23]. The objective of the 1984 Document was: 'to lay down the main aspects of government policy on water management in, both quantitatively and qualitatively'. To sum up the highlights:

- The watersystem as a whole is of primary importance. This includes everything that is related to the system; water; lake- and riverbeds; banks; salt-marshes and mudflats in tidal systems; infrastructure like rivers, lakes, canals, dams, dikes, barrages and pumping stations; substances that are contained within the water; and not to forget the living creatures and the live communities.
- The wishes expressed by society and the possibilities offered by individual systems were brought into line and choices were made.
- All aspects of water management are required to be included as part of a balanced decision-making process, taking full account of the interrelationships involved. This concerns; safety; agriculture, homes, industry, electricity supply, services sector, shipping, fisheries, recreation, landscape and nature.
- A cost/benefit analysis was added.
- This explains why the operation of the watersystem has become so important. Water is no longer considered as merely a raw material or a way of transport, but the importance of a properly functioning aquatic ecosystem is now also acknowledged: The definition of water quality, as described in the IMP-s, has been integrated into this policy document: Quantity and quality were seen as inter- related subjects, as are ground- and surface-water.
- Attention is also paid to saltwater-systems, such as lakes, estuaries, and the sea.
- A main infrastructure (including the major inland freshwaters, salt coastal waters and the North Sea), managed by the government, is distinguished from a regional infrastructure managed by local authorities.
- The problems identified in the document were; anticipated local shortages of water as a result of drought; the alarming water quality coupled with transfrontier pollution; the poor quality of lake- and riverbeds; the considerable falls in ground-water levels due to extraction, in addition to the ensuing damage to agriculture, nature and landscapes that are associated with it;groundwater pollution; choosing which problems should be addressed first.

As a result the conclusions were different from those arrived at in 1968: Various, in 1968 planned, measures have been dropped; the North-South link; the canalization of the river Yssel; the development of major water supplies in the Lake Yssel; and the closing off of the river Oude Maas. Altogether a saving in investment of about 1.5 billion US $: It was recognized that the majority of problems can be solved by means of small-scale operations. Of the plans involving local waterauthorities, some 50 schemes looked promising; The direct benefit. from the smaller schemes would amount annually to 50-150 million US $, for an investment of 250 million.

3.4 The need for progress

Thus, in order to manage water successfully, the relationships between several factors must be taken into account. Integrated water management aims to manage watersystems (or landsystems where water is an essential part) together with the associated lake and riverbeds, banks and groundwater, as one complete unit in relation to the human interests. Arguments in favor of integrated water management are summed up:

- Watersystems function as entirety. The coherence in diversity must be preserved in policy.
- A large number of methods are available to control a system (level, salinity, residence time, collecting, transporting, extracting, infiltrating, separation of salt and fresh water, constructing barrages etc.). However, application must be carefully considered. You never know the ultimate impact; many utilizations have their roots in the ecology of the system, which has its limits.
- Many interested parties are involved with water systems, but all may place different sometimes conflicting demands on the system. Interests and possibilities must be weighed up in a balanced way, taking account of their interrelationship
- Water, with everything in it, is a moving part of the landscape, here today, gone tomorrow and subject to changing authorities. Intervention at one place may have far reaching consequences for quality and utilization elsewhere.

The key question today is, whether sufficient use is being made of the possibilities that water, the infrastructure and creative methods of dealing with watersystems can offer. In other words, there is more need for sustainable management and for small- scale specialized multi-functional engineering, than for new large scale hydraulic engineering projects! In the past emphasis was laid on water as a medium, its use as a raw material and as a transport route, and its protection against the harmful consequences of human activities. Sustainable management still involves distributing water and protecting watersystems from human intervention. However, the development of watersystems also deserves attention. *The wishes of society and the possibilities offered by water systems can and must be harmonized.* There must be more cooperation between nature and the way in which watersystems are dealt with. This should equally well apply when realizing or safeguarding functions of direct human interest. In practice, such an integrated way will concern various areas of policy. It could not only involve, for instance, traditional duties such as protection against flooding, the management of aspects such as quality, quantity and shipping routes, but should also relate to recreation fisheries and nature conservation. The duties and responsibilities for certain policy-areas are vested in various administrative bodies involving both the national and provincial authorities, as well as the local Waterauthorities. An integrated approach to water management must therefore include measures to coordinate these individual policy areas [3d]. Such a harmonization of policy and management by the individual authorities concerned must primarily concentrate on developing administrative agreements for each watersystem, which are then put into practice by the requisite authorities, each having their own duties and area of jurisdiction. The above shows, that the actual watersystems, the opportunities and functions that these systems represent, coupled with the harmonization of administration and management are the central elements in an integrated approach to watersystems! Such an approach also implies a greater regional differentiation in policy matters. Every individual watersystem has different characteristics and processes in addition to different functions and discharge situations. In the meantime care must be taken not to lose sight of national aspects. It must be emphasized that it is essential to have a national approach for water management based on national standards for the protection of watersystems.
There clearly exists a need among local authorities to apply the general policy in a way that accommodates the specific functions and possibilities of the systems in their areas. This strengthens the bond between standards, management objectives and the way in which the system is used.

4. LIVING WITH WATER IN THE NETHERLANDS ANNO 2000

The approach outlined above takes time and has far-reaching consequences in terms of policy. The strategy, for beyond the year 2000 should therefore be considered now. This was in 1985 proposed in the policy document 'Living with Water' [24]. Meanwhile this document has received parliamentary support. It is implemented in the third National Policy Document on Watermanagement [25]. To sum up the aspects of special attention:

- A coherent integrated national waterpolicy, based on a watersystemapproach
- Action-plans, to clean up riverbasins
- Reflection on the policy with regard to groundwater
- A harmonized policy for each watersystem
- Differentiation of emission policy for each watersystem
- Development of policies for polluted beds, non-point source pollution, banks etc.
- Effective utilization of the infrastructure and knowledge of ecology
- Reflection on the administrative and legal machinery and on the financing system.

As a basis for the third document a new Policy Analysis Watermanagement Netherlands was made. Two questions had to be answered: How can water-based flows of materials (not only water) be regulated? In which way can the infrastructure play a part in this process? This study aimed to create decision models and mainly dealt with the characteristics of the system and the control variables.

The views of the Brundtland Committee have now been accepted in The Netherlands. The principle of continuous development is at this moment the pivot of economic and ecological strategy. This also has consequences for the course of the watermanagement strategy. The third document on waterpolicy works out how an integrated watermanagement can be specified into 'worktasks' for the next decade. The aim of the policy is that 'watersystems should be managed and developed in such a way, that they can optimally fulfil their projected functions, both ecological and for human use, insofar as their inherent potentials allow'. The main concept can futhermore be divided into a number of goals:

- Guaranteeing safety against flooding and environmental calamities.
- Surveying and promoting the availability and functionality of water.
- Protecting the quality of watersystems and their further development. In other words having and maintaining a habitable and viable country as a preliminary condition.

The country needs to have sound watersystems, which guarantee a sustainable use. Watermanagement is not only intended to support the conditions necessary for the functioning of watersystems, it should also work as a steering power to define the functions that watersystems can fulfil. Taking into account the immense importance inhabitants and many sections of society attach to watermanagement, it is far from simple to give a frame within which a balanced policy is possible for various differing interests. The most important functions of the document are therefore:

- So far as integrated watermanagement is concerned, to elaborate on such concepts as sustainable development and sustainable use.
- To reach a consensus between watermanagement and the interests of spatial development, ecology and environment as seen against the background of the potentials of these systems and their functioning in an economic sense.
- To point the way in an effective and efficient integrated watermanagement.

The objectives of watermanagement for the planning period of 1990/95 are grouped into four themes, in which fifteen 'worktasks' can be distinguished:

Theme I Protection against pollution.
Worktasks; (1) Oxygen consuming substances; (2) nutrients; (3) heavy metals; (4) organic micro-pollutants; (5) beds of rivers, canals, lakes etc.; (6) calamities.

Theme II. Land-use
Worktasks; (7) banks, intertidal areas etc.; (8) restoration of watersystems.

Theme III. Control
Worktasks; (9) watersupply; (10) drainage; (11) groundwater.

Theme IV. Organization and machinery
Worktasks; (12) administration; (13) legal and infrastuctural instrumentation; (14) financing; (15) international deliberations.

The worktasks are translated in aims and goals to be realized in 1995. For example the aim of worktask (4) is; 'a reduction of, at least, 90 % of the (1989) emissions of organic micropollutants into the surface waters'. The goal for 1995 is, 'a reduction of about 50 % and for a number of pollutants 90 %'.

5. A CHALLENGE FOR HYDRAULIC ENGINEERING IN RIVER BASINS

5.1 Applications

A final word is dedicated to the applications. I would like to focus on the attacking of one of the main environmental problems of the world, the destruction of the catchment areas of rivers like the Nile, Amazone, Rhine, Donau, Ganges, Bramaputrah, Pearl river, Orinoco and the Paranah. All these riversystems and the list could be extended easily, have destructive problems in their catchment areas. The methodology of integrated planning and the development, as presented before for delta areas, can be extended to the complete catchment areas of riversystems. Three examples follow:

5.2 The Amazone river basin threatened by death

An example is the Amazone river basin. In some tributaries, barrages and man made lakes have been created, to produce electricity and many more are planned. Without an integrated watersystem approach, taking into account all barrages (also the planned ones!) and all interests involved in the riverbasin, it is impossible to avoid a disaster; neither in terms of ecological impact, nor in terms of cost/benefit in the long term. Without a careful and balanced decision making, based on policy analysis, it is not justified to decide for new investments in more barrages in tributaries in the Amazona river basin. It is another serious threat to the tropical rainforests! All the functions are at stake! In such a policy analysis there is a coherent range; The riverbasin-*system* as a unity; the *interests* associated with this area; the *potentials* of the ecosystems involved; the *machinery necessary to ensure peoples behavior and the instruments to control the processes of the system*; A *functional organization* responsible for the functional management of the riverbasin and the *financial means*. Alternatives have to be generated and assessed.

5.3 The Nile river system, a new strategy, a must

The Nile riverbasin is another wetland, where it is profitable to prepare comprehensive and up to date plans or policy options, for the development and the use of water, and water dependent land resources, comparable with the PAWN approach [22,23] in the Netherlands. But I will not go into further details.
Egypt has another potentiality I will mention, because it is another example of application, namely to take profitable advantage of the surplus in brackish water and of their coastal lagoons and waters. Egypt can make a 'golden line' of the coastal zone, by using the salt and the brackish water in that area! It requires a daring way of thinking and acting, really a challenge! Instead of reclaiming the coastal lagoons in the Niledelta, for agricultural purposes, or making fresh-water reservoirs, as suggested, one could decide to manage them as controlled estuarine ecosystems and take advantage of their unique position in the delta. Fresh water can better be used to irrigate deserts, there is plenty of room!
Another suggestion is, to make use of the so called 'useless' 10 % of the brackish Nilewater, leaving Egypt now via the Rosetta branch of the Nile, to create new productive brackish and saltwater lagoons and lakes; for example in the deserts West or East of the Niledelta, or in the shallow coastal waters. Summarizing; 'Water-reclamation'(!) is proposed instead of 'landreclamation'; the use of brackish- and saltwater in stead of fresh water... why not?

5.4 The Rhine river basin; largely degenerated

For one of the river systems, the Rhine a diagnosis is briefly worked out. In an article [26] the Rhine, its tributaries and its 185.000 km^2 of catchment area, which stretches across ten countries, are described. A diagnosis of the condition is made. Although smaller than the Volga and Danube catchment areas (1,38 and 0,8 million km^2, respectively), the Rhine catchment area contains the most water. The Rhine catchment area comes second, after the Mississippi, on the list of the world's most economically important catchment areas. Mankind has made far-reaching and large scale modifications and transformations to the Rhine and its tributaries and the catchment area. Alongside economic prosperity, the like of which is unmatched in the history of the world, substantial problems have arisen. For instance the millions of m3 of highly polluted sediments in the river forelands and in the Rhine river delta. Of these, water, soil and air pollution have attracted the most attention during the past few years. There are, however, equally serious hydrological problems as well, which have only recently become apparent. These can best be described by stating that the Rhine catchment area is simply 'drying up' at an increasing rate, due to the combined effects of several factors. It is possible that the greenhouse effect will cause the accelerated disappearance of the large water reserves stored in the glaciers within a century. The water retaining capacity of the catchment area is also becoming increasingly impaired. Further impairment of the catchment area's water reserves will have far-reaching consequences for many human activities. It may be concluded that the river system has, due to human interference, largely degenerated into a shortened, canalized, dammed and 'regulated' shipping route, held in the narrow embrace of two dikes, often used as a sewer and robbed, to a large extent, of its natural beauty. The natural watercourses have been fundamentally damaged (Fig. 5). The diagnosis of the state of art of the system finishes with five conclusion:

- The hydrological problems of the Rhine catchment area deserve at least as much attention as the problems of water quality.

fig.5 Overview of the most important dams with locks and reservoirs in the Rhine catchment area. These constructions have primarily been put into place in order to better regulate the river's water levels and to evenly distribute water drainage throughout the year.

- More attention should be paid to increasing the water storage capacity of the catchment area, with an eye to the sustainability of any solution.
- The river system's hydraulic infrastructure has come into being in an ad hoc manner, mainly in order to fulfil local needs and without realizing the consequences for the whole of the catchment area. An integral approach is necessary.
- To this day, when modifications are made to the river system the consequences for the catchment area as a whole are not realized.
- Sustainable development is not possible with the current hydraulic infrastructure and the way in which it is managed.

Nothing which could be termed sustainable development is evident at present. In the chapter 'Strategy for a solution', it is explained what is meant by sustainable development and that there are limits to sustainable use. Four sustainability functions; 'the carrying capacity-', 'production-', 'regulatory-' and 'information-functions'are used to illustrate these limitations. The limits to sustainable use are also sketched for the various sectors:

- Demands made on natural cycles and energy flows should be reduced to a minimum.
- Genetic and landscape diversity should be maintained as much as possible.
- The attempt to achieve maximum production should be abandoned, in favor of adapting to ecological requirements.
- Permanent and/or renewable resources, (e.g. sun, wind and water power) are preferable to non-permanent and non-renewable resources (e.g. fossil fuels and heavy metals).
- In the search for solutions serious consideration must be given to permanent alternatives. Politically relevant policy analyses or, as long as the economy is a dominating factor, environmental impact statements, are obvious vehicles for this.

The conclusion is drawn that water determines everything and that it is the interdependences that exist in the catchment area, due to the flow of the river and all the substances it carries, which point to the necessity of further international cooperation. The cooperative effort must pay sufficient attention to the basic functional conditions for existence, which are determined by the system and the interests vested in that area. The various factors are inextricably bound up with one another. These are: the (Rhine) catchment area; the interests at stake; the possibilities and limitations of the system; the instruments to manage the situation; the organization; and the finances. Finally seven recommendations are made, which together constitute the proposed strategy:

- *In order to achieve sustainable development it is necessary not only to do justice to the political borders between nations, but also to the natural system borders. In the river basin, the system borders coincide with the watersheds between the catchment areas and sub-catchment areas.*
- *An integral riverbasin approach should become generally accepted.*
- *Sustainable development demands an integral approach involving the whole river basin. Interests in the sub-riverbasins should be attuned to each other and to the catchment area as a whole.*
- *A first prerequisite for a sustainable approach is the public availability of accurate information concerning the actual state of affairs. Citizens and politicians have a right to coherent and sufficient information concerning the system in which they live and the consequences of their actions upon it.*
- *In order to be obtain a greater understanding of the issues involved and their interconnection, and to provide a sound basis for the making of policy decisions, it is recommended that parliamentary permission be obtained for a policy analysis concerning the entire (Rhine) catchment area.*
- *There has been intensive, practically-oriented cooperation between the countries concerned for more than 150 years, with concrete outcomes for shipping, information processing and water quality. Practically-oriented cooperation must be expanded further in the areas of hydrology and ecological recovery of the river and its environs, eventually involving the complete catchment area.*
- *Disasters (like the one at Sandoz) appear to have taken the place of scientific research and rational thought when it comes to the drawing up of adequate environmental regulations. Necessary environmental measures must not simply be thought up as a result of the pressure of public opinion, but must, above all, be based on facts. Management by knowledge must be given priority over management by accidents.*

In the world many more, small and large scale, applications are possible! The main two messages of this article were to emphasize 'the positive role man can play in his environment' and 'let engineers stop to destruct the last unaffected large river systems especially in third world countries'. Let they concentrate their creativity to restore already affected river systems like the Rhine. There is work enough to do! And don't forget 'the one who controls the water, directs and rules developments!'

REFERENCES

1. VEEN J. van. Dredge, Drain, Reclaim. The Art of a Nation. Publ.by M. Nijhoff, the Hague, the Netherlands,

1950.
2. VEEN J. van. Land below sealevel. Holland in its age long fight against water. Publ. by Trio, the Hague, the Netherlands, 1953.
3. SAEIJS H.L.F. Changing estuaries. Rijkswaterstaat Communications 32, Rijkswaterstaat, the Hague, the Netherlands: a;57-60: b;60-64: c;387-403: d;241-278/1982a.
4. SAEIJS H.L.F. From treating of symptoms towards a controlled ecosystem management in the Dutch Delta. The Lessons learned from 2000 years of living with water and ecotechnology in the Netherlands. Seminar,'The Dutch Delta', November 17th, 1988, on occasion of the Australian Bicentennial, Sydney, Australia. The Institution of Engineers Australia. 118 Alfred ST Milsons PT. 2061 Sydney. Australia. Publ. Rijkswaterstaat, the Hague, the Netherlands, 1988.
5. ADRIAANSE M., DE JONG J., VAN DER TUIN H. Historical and present day engineering aspects of lowland development the Netherlands. Rijkswaterstaat. Institute for inland and waste water treatment (RIZA). Leliestad, the Netherlands, 1986.
6. JONG J. DE, ROELOFS J.H. Ecology and the Zuiderzee Project. Wat. Sci. Techn., 16: 51-77/1983.
7. SAEIJS H.L.F., BANNINK B.A. Environmental considerations in a coastal engineering project.Hydrobiol. Bull. 12: 3/4 178-202/1978.
8. KNOESTER M. Introduction to the delta case studies. Wat. Sci. Techn.16:1-9/1983.
9. SAEIJS H.L.F. Towards control of an estuary. Proc. 4th Int Conf. On River Basin Management. Sao Paolo, Brazil, 13-15 August 1986. Publ.by ANAIS: 169-188/1986.
10. SAEIJS H.L.F. The Oosterschelde and the protection of the environment. A policy plan for a changing estuary. Rijkswaterstaat Communications 32: 241278/1982
11. KNOESTER M., VISSER J., BANNINK B.A., COLIJN C.J., BROEDERS W.P.A. The Easterscheldt Project. Wat. Sci. Techn. 16:171-206/1983.
12. FERGUSON H.A., WOLFF W,J. The Haringvlietproject. The development of the Rhine, Meuse estuary from tidal inlet to stagnant freshwater lake. Wat. Sci. Techn. 16:11-26/1983.
13. SAEIJS H.L.F., DUURSMA E.K., DAVOREN W.T. Integration of ecology in coastal engineering. Wat.Sci. Techn. 16:745-757/1983.
14. SAEIJS H.L.F., STORTELDER P.B.M. Converting an estuary to lake Grevelingen. Environmental review of a coastal engineering project. Environmental Management 6:(5):377-405.15/1982.
15. NIENHUIS P.H., HUIS IN 'T VELD J.C. Grevelingen: From an estuary to a saline lake. Wat. Sci Techn. 16:27-50/1983.
16. NIENHUIS, P.H. Eutrification of estuaries and brackish lagoons in the SW Netherlands.Proc. CHO-TNO, Technical meeting, 1989. Delta Institute for Hydrobiol. Research, Vierstraat 28, 4401 EA Yerseke, the Netherlands, 1989.
17. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Watermanagement of the Netherlands (Dutch). Governm. Publ. Office, the Hague, the Netherlands, pp250/1968.
18. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Indicative More Year Programme Water, 1975-1979 (Dutch). Governm. Publ.Office, the Hague, the Netherlands, pp 92/1975.
19. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Indicative More Year Programme Water, 1980-1984 (Dutch). Governm. Publ.Office, the Hague, the Netherlands, pp146/1981.
20. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Indicative More Year Programme Water, 1985-1990 (Dutch). Governm. Publ.Office, the Hague, the Netherlands, pp146/1986.
21. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Watermanagement of the Netherlands (Dutch). Governm. Publ.Office, the Hague, the Netherlands, 1982
22. PULLES C.W., SPRONG T.A. A policy analysis for the watermanagement of the Netherlands (PAWN). Proc.4th Congr.of Asian & Pacific Division (ADP-IAHR):1371 1387/1984.
23. ANONYMOUS. Policy Analysis for the National Watermanagement of the Netherlands. Rijkswaterstaat Communications 31: the Hague, the Netherlands 1982.Netherlands, pp253/1985.
24. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Living with Water (Dutch & English). Rijkswaterstaat, the Hague, the Netherlands, pp253/1985/1985.
25. MINISTRY OF TRANSPORT AND PUBLIC WORKS. Water voor nu en later (Dutch). Rijkswaterstaat, the Hague, the Netherlands, 1990.
26. SAEIJS H.L.F.,LOGEMANN D. Life History of a riverbasin. Towards sustainable development of the Rhine catchment area. Intern. Rhine Congr.,'Der Rhein, zustand und zukunft', Arnheim, the Netherlands, 6-7 June 1990 (German, French), in press.

Leere Seite
Blank page
Page vide