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Living with Dams

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The least we can do is to listen carefully, and to learn from each others' mistakes

ABSTRACT

Dams have proven their usefulness in preventing and mitigating floods, and water scarcity and generating electricity. They are indispensable in present society. But at the same time, they cause serious ecological, social and economical problems. Consequently we have to live with a dams dilemma, but how? Dams are changing (natural) rivers. In the decision making process the qualities and values of (natural) rivers are structurally underestimated.. These are identified. It is not the dam but the river ecosystem that has to fulfil so many wishes at the same time. Therefore it is the watersystem (on the scale of a riverbasin), and not the dam that has to be focussed on. The dam is only an instrument for management. By constructing a dam, essential environmental boundary conditions are changed. These changes cause negative effects but in the mean time they are challenging because they offer new opportunities. Pre-condition is a holistic systemic approach relying on an integrated water resource management, instead of the current fragmentation in managing water. Growing ecological knowledge and practical application (eco-pragmatism) will therefore play an increasing important role in watermanagement. Directed ecosystem development of watersystem will become within reach. The aims for (water) management of rivers are summarised. The universal principles in watermanagement are identified and applied.. Alternatives are put forward. Finally some recommendations are formulated.

1. THE DAMS DILEMMA

Man has always tried to change his environment to serve his needs. Manipulation of natural systems has been practised on an ever increasing scale, with ever increasing consequences for the characteristics and functioning of these systems. Many problems arose because man was not aware of, or neglected to take into account, the ecological laws.

Manipulation of natural systems such as rivers, lakes and estuaries have included the construction of dikes and dams, cutting off river bends, and placing sluices and weirs. These interventions serve a wide variety of purposes for different stake-

holders in society, such as industry, agriculture and civilians. Many interventions in watersystems have proved to be an effective way to solve the actual problems of these different stakeholders. However, although the effects of interventions might be beneficial for one group of stakeholders it is increasingly recognised that these interventions often also have negative effects on the functioning of the system, and thereby harm the interests of other stakeholders. The sum of the interventions might even (and often do) have a negative net total effect on the water system as a whole.
One such intervention is the construction of *dams*[2]. The number of large dams in the world is estimated at 45,000 and each year about 300 are added to this figure. The total amount of smaller dams in the word is estimated at 800.000!
Dams have convincingly proved their usefulness in preventing and mitigating floods and water scarcity and in the generation of electricity. They are indispensable in many present societies. But at the same time, they can lead to serious ecological, social and economic problems. The question that has to be answered is how this *'dams dilemma'* can be dealt with in a sustainable way.

2. THE VALUE OF NATURAL RIVERS

2.1 Value structurally underestimated

Dams are constructed in rivers .There, they are the direct or indirect cause of most of the problems they may provoke. As a result of the changing environmental conditions, landscapes will modify or even totally transform and all kinds of ecological, social and economic problems may develop. During the decision making process of dam construction the qualities and values of *natural rivers*[3] are structurally underestimated. The "do nothing" alternative, as a consequence, is seldom (or never) a serious alternative *(Saeijs, 1982)*. To reach a balanced decision, however, it is necessary to have enough knowledge about the features and potentials of the natural river, and about the new environment that is created as a result. Let's take a quick look at natural rivers. Rivers are an undeniable vital link in the hydrological cycle of water systems. Scientifically, there are three factors on which the existence of a river depends: availability of surface water, existence of a river-bed and an inclining earth surface. Rivers fulfil numerous important functions. The first and most vital function of a river is the *discharge of superfluous water* from the riverbasin along the surface of the its riverbasin. A second important function is connected with this; the *erosion and the transport of sediments*, necessary for the downstream 'erosion/sedimentation equilibrium' in the delta of the river. For example, the Assuan dam in Egypt is the main cause of coastal erosion in the Nile delta. Another important function of a river is the distribution and long distance *transport of water and additives*.

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[2] *In this article a dam is defined as a transverse over a watersystem thrown up engineering structure, to stem the water and to direct or to divide the water coarse.*

[3] *A natural river is a water course. that originated without the help of man, in which the water in a self made channel cleared a way from the higher parts of the earth surface to the lower parts, after which it mostly rushes into the sea or in a dry land area , where it by evaporation is drying up.*

Rivers are moreover environments with *unique life communities* in the water itself and on the floodplain. In this way, they contribute to global . Furthermore, rivers produce products and services free of charge (Constanza, et al, 1997) like fish, cleaning the water for drinking and irrigation, and providing space for human settlement and cultivation , unique for this type of environment.

Societies and ecosystems depend on these functions of rivers. The loss or degradation of these functions constitute real costs to society. When they are lost, the replacement value of these kind of products and services is tremendous. Think of the costs we have to pay to clean our water or to build dikes for safety reasons when these natural functions of rivers have disappeared.

> An example of the cost associated with the loss or degradation of natural river functions can be seen in the Rhine river basin (Schuijt, 2001). The Rhine has been transformed from a natural meandering river containing numerous important benefits to society into a man-made river deprived of most of its natural functions. These natural functions constitute real economic benefits to society. As a result of human interventions, natural river functions like clean drinking water provision, fish production, nature, and natural retention capacity have more or less disappeared. The loss of these natural river functions are major costs to society. For example, the loss of clean drinking water provision amounts to $663 million per year; the loss of nature equals $640 million per year; and the loss of the natural retention capacity function of the Rhine results in costs of $500 million per year. In the long run, these costs are borne by society.

It is important to realise that whatever interventions are conducted in a river basin, the river has to fulfil its functions at least at minimum level. In other words, after interventions have taken place, the river must contain at least the following essential features: enough water, sufficient dynamics (not too much, but certainly not too little), resilience, and connections between the subsystems. The importance of dynamics for rivers is illustrated by the following example.

> The transport capacity of a river is directly proportional to the sixth power of the rate of flow. A changing rate of flow, for instance as a result of dam construction, may have significant impact on the behaviour of sediments. Lowering the rate of flow then results in too much sediment upstream and too little downstream from the dam. An example of this system dynamics is the regularly occurring floods in the Nile delta during the months July, August and September. The construction of the Assuan dam abruptly ended these high discharges. However, the dam also had enormous impacts on the economically highly significant sardine population in the Mediterranean sea. In fact, the disappearing dynamics affected the entire fishery sector in the Mediterranean area, leading to an ecological and economic disaster *(Saeijs, 1982 p 39)* .

2.2 Ecosystem oriented cost benefit analyses

The natural environment is almost universally undervalued in decision making and practically nowhere is there an 'awareness of ecological costs'. The loss of natural functions as a result of hydraulic engineering projects are important costs to society that should be included in the decision making process of a project. Since these natural functions are, however, largely outside the market system, they are often excluded from such decision-making tools like cost-benefit analyses. When ecosystem functions are not incorporated in decision making, this leads to allocations that are economically inefficient. Although individual actors reap the benefits of the project, in the long run costs are borne by society as a whole. It is therefore vital to recognise the importance of natural ecosystem functions in decision making (Bouma & Saeijs, 2000).

The incorporation of ecosystem functions in decision making can be achieved by valuing ecosystem goods and services into monetary terms *(Constanza et al 1997).* Once monetary measures are found, these goods and services may be incorporated in a cost-benefit analysis, resulting in what is called an *ecosystem-oriented cost-benefit analysis*. In this way, the benefits of dam construction can be weighed against the costs (construction costs and costs of affecting the ecosystem) so that economically more efficient decisions can be made.

> The loss of estuarine environments in the deltas of the Rhine, Meuse and Scheldt is a good example of the effects of excluding natural environments in decision making processes *(Saeijs, 1999).* Of the original 8,660 km2 of estuaries in this delta in 1900, there remain only 3,930 km2 in 2000: more than 54% of estuarine environment (4,730 km²) has disappeared within one century. When Costanza's key figures (1997) are applied to these estuaries and
>
> the new systems, the Gross National Nature Product of the estuaries in 1900 is estimated to have been ca. $[4] 16 billion per annum. These watersystems would presently represent a capital value of ca. $ 336 billion. Of course, the figures are not absolute, but indicative. However, the message the figures convey is clear. Taking in account the gains of the new land and lakes, the loss in national nature product amounts to $ 8.8 billion per annum while the net production loss can be estimated at $ 6.6 billion. The net loss in capital is estimated $ 138 billion. These costs of estuarine destruction have never been included in decision making tools like cost-benefit analyses during projects like the so-called Zuyderzee project and the Delta project. Current policy is aimed at (where possible) restoring estuarine environments. This too will cost a fortune.

Decision-making in water management is quite frequently dictated by disasters. The challenge is to meet decisions based on rational arguments including long-term cost-benefit analyses to avoid disappointments. The time has come for economists and ecologists to work together. This will certainly result in new instruments for ecosystem management and perhaps in new applications of eco-economics.

[4] *One USD was about f 2.40 (Dutch Guilders)*

3.. HUMAN INTERVENTIONS IN RIVER SYSTEMS

3.1. The sum of 'the whole' is more than the sum of the elements

Constructing and managing dams cannot be seen as isolated activities (Fig. 1): the sum of 'the whole' is more than the sum of the elements *(Saeijs, van Westen & Winnubst, 1995)*. As a result of the need for e.g. safety, new land, cleaning wastes, and navigation, the impact on river systems by men is in most rivers tremendous. Each stakeholder of a riverbasin has his own priorities and seldom does he look over the boarders of his own sector to the impact on other activities in the entire riverbasin, or at the interrelationships between activities, or to the long term impact of his activities.

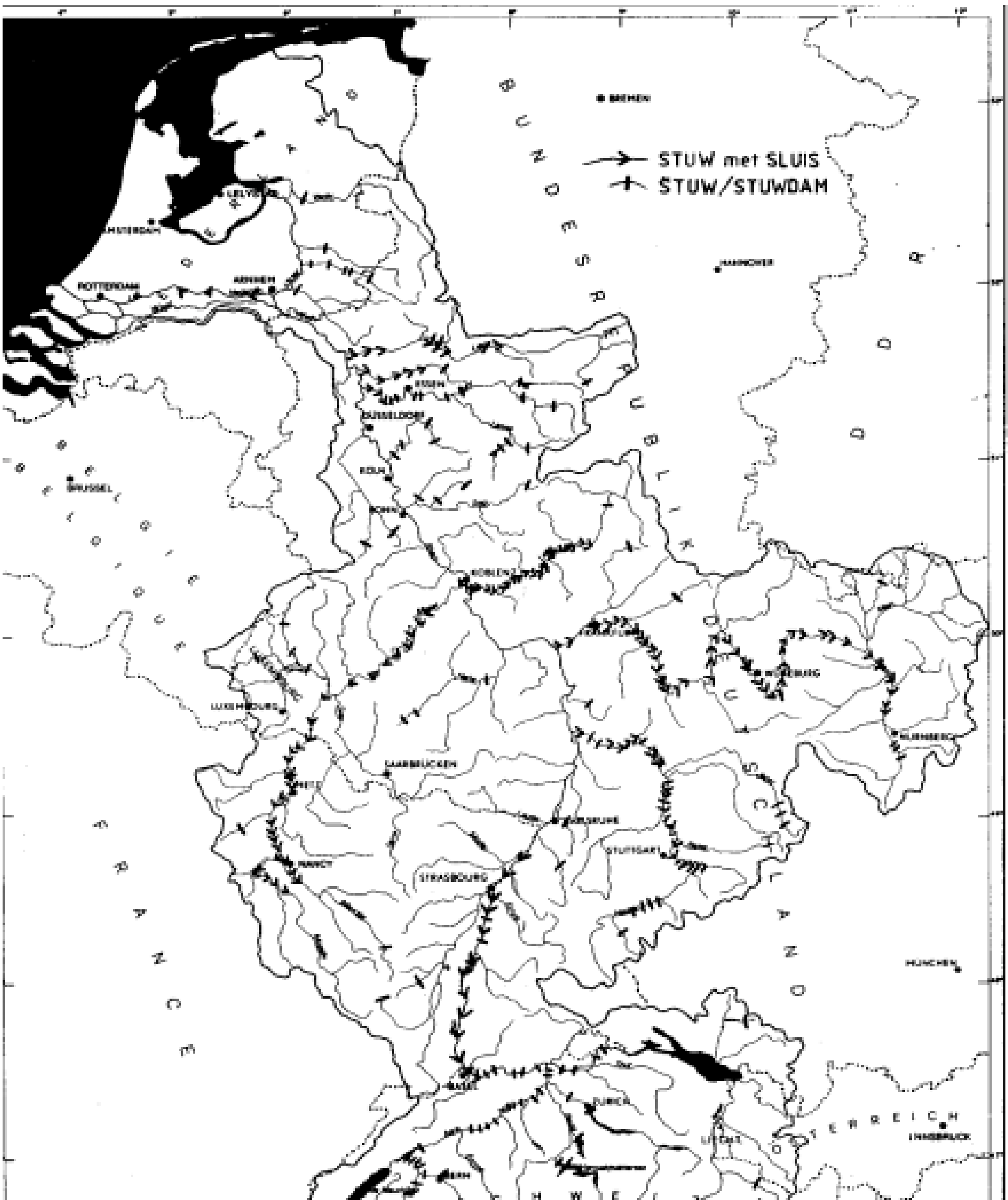

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Fig. 1 About 480 dams, sluices and weirs were constructed in the river Rhine and its tributaries. The impact of all the structures together is much more than of each structure alone. The sum of 'the whole' is more than the sum of the elements

The negative effects of dams that are becoming increasingly recognised are often the result of century-long activities in the wrong direction.

> For example, the cause of ever increasing water levels in The Netherlands is a result of 500 years of land reclamation in the floodplain and un-sustainable use of the rivers' resources.

3.2 Dam impacts

There are many different dams:

> Distinguished to used materials; earth fill -, rock fill-, and concrete dams; distinguished to environment: dams in mountains, on plains, in lower parts of the river or delta areas and, in estuaries; and distinguished to main objectives for the construction of dams for hydropower, water storage, safety or land reclamation.

Evident is that the role of so many different dams cannot be caught in one single statement. Each group of dams needs its own attention: *"think global, act local" (Cosgrove & Rijsberman, 2000).*
Dams have both benefits and concerns. (World Commission on dams, 2000)
The main *benefits* of dams include the mitigation of floods, water supply for human needs and crops, navigation during periods of drought, recreation, recharge of groundwater basins, hydro electric power, and so on .
The dominating *concerns* of dams are safety risks, displaced persons, illnesses and diseases, a wide variety of environmental problems, the ruining of groundwater by reservoirs, sedimentation upstream of the dam, downstream salt up, and erosion in deltas.
At times, the ecological problems dominate (such is the case in the Aralsee), at other times social problems (the case of the Narmada dam in India) and economic problems (the case of the Ataturc dam, Turkey) may dominate

> Turkey with more than 600 dams constructed in the last fifty years; a tremendous performance. For the next fifty years another 600 dams are planned. Most of the dams are constructed to generate hydro electric power. Economic arguments dominate in the decision process , because the income and other benefits are vital for the economy and development of the country. But a high price is paid (and will be) as a result of the loss of river integrity.

In the decision making process it is important to realise that it is not the dam but the specific problem at hand that needs special attention. The dam is only an instrument in river(basin) management, nothing more, nothing less. *Therefore, the focus must initially be on the management of the water system.* Then, all available options for the water system that help solve the problem need to be assessed. Once a dam is chosen as a preferred alternative, the impact of the dam on society and the environment, including the challenges of the new environment that is created, must be estimated. After all after dam construction, management of the entire river basin must continue.

4. CONTEMPORARY APPROACHES IN WATER MANAGEMENT

4.1 Integrated water management in the Netherlands

In the course of 2000 years, hydraulic engineering activities in The Netherlands changed from small-scale to large-scale, defensive to offensive, short-term to long-term, specific to multifunctional, conflicting to harmonious, and from stemming the tides to controlling them. The local coastal engineering measures in the 1^{st} to 11^{th} centuries turned into well-organised dike building programmes from the 12th century onwards. Land-reclamation from inland lakes. was carried out since the 16th century, which changed into large-scale and complex transformations in the 20th century. A universal pattern developed, illustrating that wherever in the world authorities are dealing with water, they will sooner or later 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 behaviour (laws etc.) and to control
- *the processes* of the system (sluices, barrages, dams, pumps, models etc.);
- *the organisation* responsible for functional management;
- *the financial means*

Experiences in the Netherlands with two big civil engineering projects last century, the Zuyderzee project (safety, water storage and land reclamation) and the Delta project (safety, water storage) have resulted in a revolution in water management that is now known as an *'Integrated water system approach'.* (*Saeijs,& Bannink, 1978, Saeijs 1982, 1983, 1986, 1987, 1988, 1999;;; Saeijs, Ministry Public Works and Watermanagement, 1985; Duursma & Davoren, 1983; Saeijs & Logemann, 1990, Saeijs en Turkstra.1994)*. This new type of Dutch water management has had its impact on the conferences in Rio de Janeiro (1992) and Dublin.

4.2 The need for a radical change

In order to manage water successfully, the relationships between several factors must be taken into account. Integrated water management aims to manage watersystems (or land systems where water is an essential part) together with the associated lake and riverbeds, banks and groundwater, as one complete unit in relation to human interests. Integrated water management is a major step towards radical change in the management of the world's water systems as it recognises that:

- The water system 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 functions of rivers, lakes, canals, dams, dikes, barrages and pumping stations, substances that are contained within the water, as well as the living creatures and communities.
- Many interested parties are involved in water systems. However, 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 interrelationships.
- Water systems function as an entity. One system cannot fulfil all the demands of different subsystems and stakeholders at the same time. The coherence in diversity should be preserved in policy.
- The wishes expressed by society and the possibilities offered by individual systems should be brought into line, and although watersystems are multifunctional, choices should be made.
- 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 utilisation elsewhere.
- 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, settlement, industry, electricity supply, service sectors, shipping industry, fisheries, recreation, landscape and nature.
- Water should no longer be considered as merely a raw material or a way of transport, but acknowledge the importance of a properly functioning aquatic ecosystem. Quantity and quality should be seen as interrelated subjects, as are ground- and surface-water.
- Main infrastructures (including the major inland freshwaters, salt coastal waters and the continental shelf) that are managed by the government, should be distinguished from a regional infrastructure, managed by local authorities.

The key question today is whether sufficient use is being made of the possibilities that water, infrastructure and creative methods of dealing with watersystems can offer. For example, in developed countries like the Netherlands there is more need for sustainable management and for small- scale specialised 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 should be harmonised.*

4.3 Aims for water management in the 21st Century

The World Water Counsel *(Cosgrove & Rijsberman, 2000)* formulates the aims for water management for this century as follows:

>> “Water is life. Every human being, now and in the future, should have access to safe water for drinking, appropriate sanitation, and enough food and energy at reasonable cost. Providing adequate water to meet these basic needs, must be done in an equitable manner, that works in harmony with nature. For water is the basis for all living ecosystems and habitats and part of an immutable hydrological cycle that must be respected if the development of human activity and well being is to be sustainable.” << They continue:
>> “We are not achieving these goals today, and we are on a path leading to crisis and to future problems for a large part of humanity and many parts of the planet’s ecosystems. Business as usual leads us on an unsustainable and inequitable path.” << *(See also; Saeijs & van Berkel 1995, Saeijs en Korver 1999).*
As a basis for decision making there are many who see water as a resource only for human uses. In the new approach water is recognised too as a vital part of ecosystems, on which all nature services, products and functions necessary for life on earth depends. Others look at political and administrative boundaries and sovereignty as basis for decision making. In doing so, it is seldom conform to the interests in the entire riverbasin. A narrow-minded or fragmented approach can lead to costly damage and restoration projects .

> A good example of a water system that has been viewed primarily as a system for human use throughout history is the Rhine river basin. It has been transformed into a ship channel within almost one century. It is bordered by dykes and about 480 locks, weirs and dams have been constructed in its river basin (Fig. 1).
> The river has been shortened by 25%. The harnessing of the river with dikes, land reclamation, uncoordinated management of all civil engineering structures, together with climate change, has resulted in more and more “flood waves”. As a result new measures need to be taken to enhance the safety level in the basin countries. These measures include, next to the reinforcement of dikes, “declamation“[5] to create more room for the river and bringing back the ecological flood regulating services of the river. In this way, many billions of dollars are now spent on the restoration of the river.
> To give an indication of the dimensions of the costs of these river rehabilitation, $1.8 billion is allocated for the “Room for the Rhine” project, aimed at managing floods by bringing back the ecological functions of the Rhine delta (including the reservation of retention areas and giving the river more space for natural flooding). Furthermore, $40 million has been spent between 1970 and 1990 for the construction of waste treatment plants along the Rhine as a result of heavy industrial pollution, while an additional $300 million needs to be invested to clean up the most heavily polluted sediment of the Rhine delta. These investments prove that natural functions of rivers are not dispensable as we once thought.

The wishes of each group of stakeholders of a river basin are understandable, perhaps feasible, seen from the perspective of the single stakeholder. However, taking the demands of all the stakeholders as a whole often results in devastation of the river system and causes costly problems. It is obvious that there is a need for tuning the demands among the different stakeholders in river basins.
Achieving the aims of the World Water Counsel and achieving a sustainable future for river systems and river basins requires drastic changes in the way water is managed. “An holistic systemic approach relying on integrated water resource management must replace the current fragmentation in managing water” *(World Water Counsel, (Cosgrove & Rijsberman, 2000)*. An holistic or integrated approach implies water management that aims at connecting water tables , shores, and

[5] *Declamation* is the opposite of reclamation,. to give land back to the floodplain of the river or to the sea

groundwater with all the materials, life communities and processes, as well as involved interest groups and stakeholders, in a comprehensive and unified approach.

4.4 Globalisation of the new approach

Increased awareness of the natural environment and its endangered situation is one of the most important developments of the late twentieth century. The United Nations “Declaration on the Environment” and the Club of Rome’s message in the “Limits to Growth” left their mark on our thinking in 1972, followed in 1987 by immediate and world-wide agreement on the g concept of *sustainable development* as propagated in the Brundtland Report of the United Nations entitled ”Our Common Future”. In 1992, the United Nations Conference on Environment and Development (UNCED) put the issue into a global perspective and drew up a comprehensive action program in Agenda 21. This program stated, among others, that in order to meet sustainable development objectives, one should try to strike a balance between water and other natural resources. The most important strategic principles formulated at the UNCED conference were:

- Policy and management need an integrated approach at the level of an entire river basin.
- Management of water resources needs to be developed within a total package of policy measures on human health, production, protection and distribution of food, prevention and solution of accidental events,
- Environments need to be protected and natural resources conserved.
- Water management requires an integrated approach , based on the awareness that water is an inextricable part of the ecosystem and that water is also a social and economic asset.
- Priority must be given to (1) fulfilling basic human needs and (2) at the same time protecting the earth’s ecosystems.

These five basic principals (main recommendations) should be constraints for dam building and river (basin) management.

Next to these basic principles a number of institutional principles are applied like; the cause principle; the polluter pays principle; the equality principle; the profit principle; the sovereignty principle; the intergeneration principle, and the precaution principle.

5. DAMS AND THE MANAGEMENT OF ECOSYSTEMS

5.1 Resilience of ecosystems

When damming parts of rivers, the determining abiotic circumstances of the river basin should not be altered beyond the natural fluctuations of the natural river basin. When the effects (for example due to artificial reservoirs) remain within the limits of this natural *resilience*[6], no harm is done to the natural system. In that way, irreversible effects on ecosystems, and thus the negative impacts on socio-economic

[6] *Resilience is (in this article) the ability of a river (eco)system to recover quickly from a setback such as caused by construction of a dam, or even a disaster*

and environmental aspects, are avoided.

The challenge for each *new project* is to find out what the resilience is and how not to go beyond the limits of that resilience. (It is, for example, important to realise that the resilience for abiotic and biotic changes fluctuates with the seasons). The challenge for each *existing project* is to investigate what should be corrected in order to restore a situation in which the effects of the reservoirs stay within the limits of the resilience of the natural ecosystem of the river basin.
This provides a logical explanation of the concept of sustainable use. Disturbing a river basin by human activity should never have a greater impact than the natural ranges and frequencies of disturbances that the natural river basin has to deal with. The word 'natural' is important here: the disturbances caused by human abuse of the river basin in the past shouldn't be taken into account of course.
Following this , the flow of a river should never be completely dammed, because making a stagnant lake of a stretch of river clearly goes beyond the borders of the resilience of a natural river. Only parts of the flow should be used for reservoirs made in bypasses of the main stream only. Dams may offer many advantages but as soon as they are constructed on such a scale that the resilience of the natural system is eroded, they cease to be sustainable. Construction of small-scale dams instead of large-scale dam-building should therefore be considered as a viable option.

5.2 Directed ecosystem development

If transformation is unavoidable it must be directed in such a way as to permit eventual replacement by healthy ecosystems in an area where other but equally vital natural functions can be fulfilled. These kind of systems and changes require special caution, but must always be geared to achieve the most beneficial combination of the functions of man and nature.
According to this line of thinking, the prevention of human activity is not an objective and certainly not an objective in its own right. The basic premise must be that the functioning of an area must be tailored to the needs of society on the condition that the ecosystems involved can continue to function in a healthy way. The foregoing raises three points that require particular attention:

- Man has the right to make use of an area and to direct developments in a desired direction. At the same time it forces man to take care of the process and the final result - healthy functioning resilient ecosystems. It makes little sense to deny or frustrate this right in its most essential form. The emphasis in man's concern must be on better and more aware preparations for and supervision of change, with more systematic underpinning and ecological feelings. Of course 'the profit principle' is applicable (the one who has the profit has to pay all the costs, including the extra management costs like dredging of upstream sedimentation)
- If we are to arrive at a better mode of decision-making concerning dams in river or estuarine ecosystems, particularly with respect to the 'ecosystems right' to protection as a type of environment, we must fully appreciate the ecosystems' characteristics and potential. Perhaps we must also learn to value them more highly and more consciously and to reflect this in our administration, management, and use of them. All too often the river or estuary as environmental types are disrupted or destroyed with no realisation of the productivity, and variety

of life and potentiality that has been lost in the process.

- If the decision is taken to intervene, the changes or transformation must be thoroughly prepared (e.g., by research), guided, and kept under review. These are at least as essential components of a large-scale hydraulic engineering project as the structure that is built.

In decisions on matters of this kind, not only the aspirations already present in society (i.e., the primary social interests) but also the (potential) opportunities must be taken into account. This means that decisions that will result in changes must not be taken unless the existing situation (the 'do nothing' alternative), including the planned improvements, is studied at each stage. The results of these studies must be incorporated at each stage of the decision-making process. Before any decision with major consequences for the systems is taken, it must first be known which natural resources (capital) will be lost by the change and what will be gained.
The studies must cover technical and socio-economic as well as ecological aspects. *The point is not to prevent change (even if this were possible) but to channel the*

process of change along the right lines. This requires an integrated policy plan on land-use, spatial organisation, and management, to be implemented in stages and have flexibility as to new changes and unknown factors.

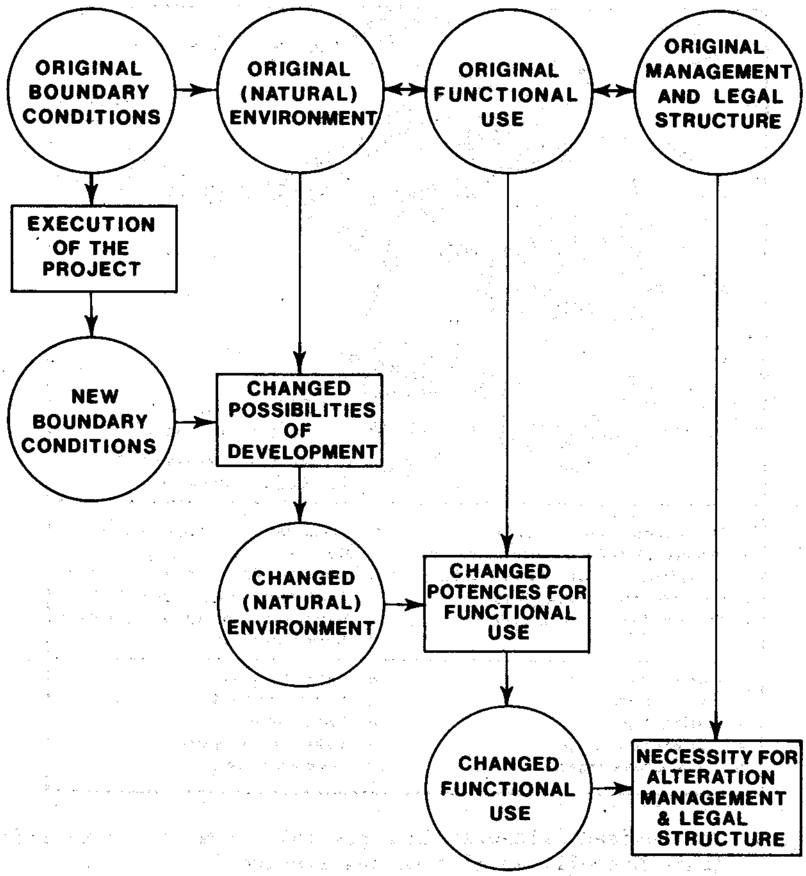

Fig. 2 A chain of results as a consequence of a major human action in the

environment (Saeijs, Bannink 1978)

Eco-pragmatism[7], (Saeijs 1999) will become increasingly important. Perhaps it will become the paradigm in watermanagement of this century. The management strategy of '*Directed Ecosystem Development*'[8] a way of adaptive environmental assessment, design and management (Holling, 1980) spans the entire process starting with the drafting of a project, through its implementation, and ending with the follow-up review. In terms of concern for the environment, this implies the following:

- Environmental aspects must be included right from the start of preparations for the formulation of policy and be given the same importance as economic and social considerations so that policy making can benefit from natural forces and even enhance them;
- The policy-design stage must comprise periods of intensive innovation followed by periods of consolidation;
- Policy must be framed such that some advantage can be drawn from a growing pool of information on socio-economic and environmental effects;
- Research designed to yield information must form part of an integrated research plan;
- The review machinery and the control mechanism must also be an integral part of the policy design on a par with the other components, and not simply be tackled at the end, once everything is completed.

5.3 Challenges of modification and transformation processes

There is quite rightly a great deal of attention being devoted to threats and negative effects of dams. However, too little attention is being given to opportunities and possibilities of the new systems and their potential (Saeijs, 1978, 1982, 1994). Emphasis must be put on greater awareness of the many stakeholders involved, especially on the ecological implications of the project, and the necessity to incorporate *flexibility* that will make it possible to cope with changes and unexpected developments, and on recognition of the fact that processes are being dealt with. The alternative, comprising preservation of the existing situation (the 'do nothing' alternative), must play a much more important role in future preparations and decision making. If a civil engineering structure is inevitable, the process of modification[9] and transformation[10] undergone by an area as a result of hydraulic engineering works must be considered at least as worthy of attention as the process of designing and constructing the works themselves. Both processes must play an important part in decision-making, from the preparatory stage to the after-care stage.

Furthermore, a sectored approach must be avoided. Every effort must be made to achieve an integrated approach, taking the basin as a whole as the model. This demands smooth administrative co-operation. Multifunctional considerations should

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[7] *Eco-pragmatism is a pragmatic application of ecological knowledge in assessment, design and management of ecosystems like river systems, to direct the development of the ecosystem in a desire direction*

[8] *Related concepts : Guided-, Planned-, Controlled- Ecosystem Developmet*

[9] *For example an estuary (Easternscheldt in the Netherlands) is modified from an open into a controlled estuarine environment with a reduced tide as result of a storm surge barrier.*

[10] *For example an estuary (Grevelingen, the Netherlands) is transformed into a saltwater lake .*

be given greater weight in the design of hydraulic projects. In this connection, more attention should be given to their function as an eco-technical management tool. Wide freedom of management must be incorporated into the design, to offer greater flexibility in response to changes, unanticipated events, new views on management; and such hydrodynamic works must be seen as subsidiary (as regulatory instrument) to the ecological and social functioning of the systems they can exert an influence on. A probabilistic approach to the design must therefore be related not only to the primary functions and the existence of the construction but also to the (future) requirements for modification, transformation, and management of the region that is affected. Decisions to execute hydraulic projects in regions for which (future) management plans do not exist must therefore be considered premature. The objective is not to resist change but to guide it properly. Ways to achieve these goals are indicated in the thesis ‘Changing estuaries’, (Saeijs, 1982)

Also the learning process is receiving too little attention both within the project and between dam projects. International organisations like ICOLD and the World Commission on Dams should promote examples of dams that contribute to sustainable development. Examples of (existing and planned) projects, which are not contributing to sustainable development, should be mentioned to the world explicitly.

6. APPLYING THE PRINCIPALS IN PRACTICE

6.1 Integrated river basin planning

There is an urgent need for *management plans* at the level of entire river basins. Sustainable development, management and use of natural (water) resources require integrated river basin planning. Dams could play a role in these plans, but they are not the first essential matter of concern in relation to sustainable development. In Europe the water policy of the European Commission is evolving from individual guidelines concerning different aspects (like water quality standards, pollution control, swimming water etc.) to a more integrated framework directive on water management. An important basic principle within the guideline is the organisation of water management at the level of an entire river basin. River basin authorities should propose and implement (not only with respect to water quality , but also water quantity issues) action programmes in order to solve the problems.
The long-term conservation of natural resources and the services they deliver to humankind (is a main objective of river basin plans so that a multiple and wise use of natural resources can be safeguarded for us and future generations. Many projects are carried out to serve local, regional or national needs without taking into account the real causes of problems and the effects of these projects on the entire river basin. Wide-ranging consideration must be given to the question of how the river basins should be managed internationally in the next century. Political decisions about water management issues may be motivated by short-term strategies but based primarily on an explicit long-term strategy. Therefore, an integrated river basin vision needs to be formulated for every river basin on earth.

6.2 Organisational arrangements

Management of water systems should also be organised at the entire river basin level. The basis should be laid by an international (holistic) evaluation study, followed by a policy analysis at the river basin level. In order to activate this international management of the river system, a step-by-step approach is perhaps the correct method:

1. Development of a Co-ordinating Committee;
2. Set-up a River Basin Commission;
3. When the time comes for this, set-up a Management Authority, with appropriate powers. The task package of this management authority might include: quantitative and qualitative water management; environmental protection; integrated management of existing infrastructure; ecological recovery of the river system; and co-ordination and harmonisation of new infrastructure construction.

6.3 Translation into a river basin action plan

In order to come to an integrated river basin action plan, five important steps should be undertaken:

- As a first step, a clear description should be made of the state of the art in a river basin. What are the general features, what are the ecological and economical characteristics, what are the human interests? What are the borders of the natural resilience of the river basin? What sort of dams and other infrastructure are present in the river basin.
- Secondly, a problem definition should be made at the level of an entire river basin, including five major area of concern: protection from flooding (1), transport (2), energy demand (3), water availability and distribution (4) and maintenance of and ecological services. The abiotic factors are the basis for the that is present. This will continue as long as there is abiotic diversity. Or as long as there is no substantive change to it. Within the resilience of the ecosystem they can survive without permanent injury. (5). Socio-economic and ecological problems should be identified. Key-factors in inhibiting sustainable development should be identified.
- Thirdly, a long-term cost-benefit analysis, based on sustainable development of natural resources, should be set up for the entire river basin in its present state. Also long term cost-benefit analyses should be made for proposed solutions (step 4).
- Fourthly an inventory should be carried out of possible solutions to solve the problems. Active participation of stake-holders is highly desirable. In this respect it is very important to consider a (large) dam or a series of dams as one of the possible instruments/alternatives for solving (social) problems, rather than as an objective in itself. When considering a dam project, the long-term costs to society and the environment should be studied and compared with these of alternative solutions.

- Finally, recommendations should be formulated for a sustainable management approach for the entire river basin. A river basin action programme should be formulated and approved by the governments and stakeholders involved

7. CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this article can be summarised in the following main points:

A need for change

We are facing a dams dilemma. Business as usual leads us on an unsustainable and inequitable path; drastic changes in approaches and attitudes towards dams and river basin management are inevitable. Water is the basis for all living ecosystems and habitats and part of an immutable hydrological cycle that must be respected if the development of human activity and well being is to be sustainable. Societies need to provide space for opportunities to solve the problems they face in other ways than only through the construction of dams in river basins

Ecosystems in decision making

In the decision making process the qualities and values of natural rivers are structurally underestimated. The "do nothing" alternative, as a consequence, is seldom (or never) a serious alternative Dam**s** are constructed in rivers, where they are the direct or indirect cause of problems, but also challenges. Societies depend on the proper functioning of rivers. Therefore, the loss or degradation of river functions constitute real and high costs to society.

An integrated approach

A sectoral (fragmented) approach towards water management can lead to costly damage and expensive restoration projects. Therefore, an integrated approach towards water management is required. Integrated water management is based on the awareness that water is an inextricable part of the ecosystem and that water is also a social and economic asset. Human interventions in river systems, like dam building, must take into account the relationship between all the different interventions. Constructing and managing dams cannot be seen as isolated activities: the sum of the whole of actions is more than the sum of the elements. The effects of interventions must be assessed at the scale of the entire river basin and over the long term. Sustainable development, management and use of natural (water) resources require integrated river basin planning, and the wishes of society should be attuned to the possibilities of the ecosystem.

Focus first of all on the problem, not on the dam

The starting point in water management is the entire water system. The water system creates the conditions for solutions, which may or may not include a dam.
The dam must therefore be seen as an instrument in river(basin) management only, nothing more, nothing less. This should be at the basis of all decision making processes: the focus should be on the management of the watersystem and on the problems to solve.

Organisation at the level of a river basin

Organisation of water management should enclose an entire river basin. River basin authorities should propose and implement action programmes in order to solve the problems. The long-term conservation of natural resources and the services they deliver to humankind (e.g. productivity, water retention, energy, clean water for all kinds of purposes, biodiversity) is the main objective of river basin plans, in order to safeguard a multiple and wise use for us and future generations.

A Vision and a river basin plan

There is first and foremost a need for a long term vision and short term agreements in river basin management. Water must become a structured element in spatial planning. Constructive co-operation and co-ordination of water policy in the riverbasin area is absolutely essential. Furthermore, there is an urgent need for management plans at the level of entire river basins. Dams could play a role in these plans, but they are not the first essential matter of concern in relation to sustainable development – this is the river basin

8. REFERENCES

Bouma J. & Saeijs H.L.F., 2000. . *Eco-centric cost benefit analysis for hydraulic engineering in river basins.* New approaches to river management ed A.J.M. Smits, P.H. Nienhuis & R.S.E.W. Leuven. Backhuys Publishers, Leiden, 2000 .

Constanza et al, 1997. *The Value of the world's ecosystem services and natural capital.:* Nature vol. 387 (15): 253-260.

Cosgrove W.J. & Rijsberman F.R, 2000. *World water Vision Making water every bodies business.* World Water Coumcil

Holling, C.S., 1980. *Adaptive environmental assessment. Int*. series on applied system analyses.3. John Wiley & Son. New York.

Ministry Public Works and Watermanagement, 1985. *Living with Water* Publ. By the Ministry

Saeijs, H. L. F., 1982. *Changing estuaries; a review and new strategy for management and design in coastal engineering.* Communications 32.. Directorate General for Public Works end Water Management, The Hague.

Saeijs, H.L.F., 1986. *Towards control of en estuary.* Proc. 4th Int. Conf. On River Basin Management. Sao Paulo, Brazil, 13-15 August 1986. Pub. ANAIS: 169-188.

Saeijs, H. L. F., 1987. *Integrale Wasserwirtschaft. Ein neues Bewirtschaftungskonzept für die Niederlande.* IAWR (Internationale Arbeitsgemeinschaft der Wasserwerke im Rheineinzugsgebied. Kongress, 11. Arbeitstagung 20-23 Oktober 1987, Noordwijk Proc. 40-76

Saeijs, H.L.F., 1988. *From treating of symptoms towards a controlled ecosystem management in the Dutch Delta. Lessons learned from 2000 years of living with water and eco-technology in The Netherlands.* Seminar 'The Dutch Delta', 17 November 1988, on occasion of the Australian Bicentennial, Sydney, Australia. The Institute of Engineers Australia. Pub. Directorate General for Public Works and Water Management, The Hague.

Saeijs H.L.F. ,1992, 1994. *Creative in a changing delta. Towards a controlled ecosystem management in The Netherlands*. Proc. IABSE 14th Congress, 1-6 March 1992, New Delhi, India. Post Congress Report 97-109. And Proceedings, 18th ICOLD-Congress, 6-11 November 1994, Durban, South-Africa. Question 69; R.25: 371-395.

Saeijs H.L.F., 1999. *Levend water is goud waard.* (Living water is worth gold) Proc. Symposion *Het Verborgen Vermogen,* 26 march 1999, (at the occasion of the leave of Prof. Dr. H.L.F. Saeijs as Chief Engineer Director of the Directorate Rijkswaterstaat, Zeeland). Publ. Rijkswaterstaat, directorate Zeeland. Middelburg 5978 (Dutch).

Saeijs, H. L.F. and B.A. Bannink, 1978. *Environmental considerations in a coastal engineering project.* Hydrobiol. Bulletin 12: 314, 178-202.

Saeijs H.L.F. & van Berkel M.J. 1995. *Global water crisis. The major issue of the 21st century; a growing and explosive problem.* Lecture on the Symposion "BOTH SIDES OF THE DAM", Organized by Technical University of Delft and NOVIB, 22 February 1995, Delft,. European Water Pollution Control. Publ.. Elsevier. Vol. 5 ,. 4 : 26-40

Saeijs, H.L.F., E.K. Duursma and W.T. Davoren, 1983. *Integration of ecology in coastal engineering.* Wat. Sci. Techn. 16: 745-757,

Saeijs H.L.F., I.A. Flameling & Adriaanse L.A., 1999. *Eco-pragmatisme* , *Omgaan met rivieren, delta's, kust en zee in de 21ste eeuw.* Boek: *'De Staat van Water'. Opstellen over juridische, technische, financiele en politiek-bestuurlijke aspecten van waterbeheer.* Eds. A van Hall, Th.G. Drupsteen & H.J.M. Havekes Uitg. Vermande: pp 29-42..(Dutch).

Saeijs H.L.F. & L. Korver-Alzerda, 1999. *Coping with a World Water Crisis. Managing water in and around the city: an ecological approach.* 34th International Planning Congress ISOCARP/AIU. 26th September - 2nd October 1998. Ponto-Delgada, Azores. Theme ; ''Land and Water. Integrated planning for a sustainable future.'' (Key note speech) Proceedings/Final Report 15-35.

Saeijs, H.L.F. and D . Logemann, 1990. *Life history of a river basin; towards sustainable development of the Rhine catchment area.* Proc. Congress 'Der Rhein, zustand und zukunft 'World Wildlife Fund, Tagungsbericht 5:12-50.

Saeijs, H.L.F. and E. Turkstra, 1994. *Towards a Pan-European integrated river basin approach plea for a sustainable development of European river basins.* European Water Pollution Control, 4 (3): 16-28.

Saeijs, H.L.F. and M.J. van Berkel, 1995. *Global Water crisis: The major issue of the 21st century; a growing end explosive* problem. European Water Pollution Control. 5-.(4), 26-40.

Saeijs H.L.F., Van Westen C.J. & Winnubst M.H, 1995. *Time for revitalisation of the Rhine.* Symposium "'The need for water. Storing water in riverbasins" July 6,1995, Oslo, Norway. During the executive Meeting of ICOLD (International Commission on Large Dams), 2-8 juli 1995, Oslo. Proc. Reservoirs in river basin development. Santbergen & van Westen (eds). Balkema, Rotterdam. ISBN 90 5410 5593 p.p. 3-24.

Schuijt K.D. 2001, *"The Economic Value of Lost Natural Functions of the Rhine River Basin - Costs of Human Development of the Rhine River Basin Ecoystem"*, Publikatiereeks nr. 36, Erasmus Studiecentrum voor Milieukunde, Erasmus University Rotterdam, 2001

World Commission on Dams, 2000. *Dams and development.* Earthscan Publications Ltd London and Sterling VA

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1. Many rivers are too valuable to construct dams in it. The do nothing alternative should play a dominant role in future preparations and decision making.

2. When damming parts of rivers, the determining abiotic circumstances shouldn't be altered beyond the fluctuations of the natural river basin. Dams may offer many advantages but as soon as they are on such a scale that the resilience of the natural system is eroded, they cease to be sustainable. So, consider recommending small-scale dams instead of large-scale dam-building

3. Never construct one or more dams in the mainstream of a riversystem, nor in all tributaries. Use only some tributaries for that purpose.

4. Design and construction of dams should include the conservation of the main functions of the river system at least at an acceptable minimum level.

5. If dam construction is inevitable, the process of modification and transformation should be considered at least as worthy of attention as the process of designing and constructing the works themselves. Both processes must play an important part in decision-making, from the preparatory stage to the after care.

6. Replace where ever possible reservoirs for large wetlands upstream with a high retention capacity