Netherlands Experiences with Integrated Water Management

Considerations for International Cooperation

Netherlands Committees for the IAH, ICID, IAHS, EWPCA and IAWQ

NETHERLANDS EXPERIENCES WITH INTEGRATED WATER MANAGEMENT, Considerations for International Cooperation

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Netherlands Experiences with Integrated Water Management, Considerations for International Cooperation

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- TNO Institute of Applied Geoscience

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- Netherlands Society for Water Management NVA

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PREFACE

During the last decade remarkable developments with respect to water management took place in the Netherlands. The policy to integrate the management of water quantity and water quality of both surface and groundwater with the aim to serve all of the water-related interests and to harmonise these interests with the need for a healthy environment, led to principles of sustainable development. This is illustrated by the introductory lecture of Mr. G. Blom, General Director of Rijkswaterstaat. Moreover, the integration of water policies urged the Netherlands Government to reorganise many of the existing water institutions, some of which date from the Middle Ages. International basin-wide water management cooperation with respect to rivers and the North Sea was also promoted.

The developments as discussed during this symposium will receive international importance when they will be introduced at the "Second UNDP Symposium on Water Sector Building-experiences, models, tools" to be held in April 1996 at the International Institute for Infrastructural, Hydraulic and Environmental Engineering IHE of Delft, The Netherlands. The results of the UNDP seminar in their turn will be helpful in preparing the United Nations Conference on Human Settlements HABITAT II, to be held in Istanbul, Turkey in June next year.

"Netherlands Experiences with Integrated Water Management, Considerations for International Cooperation" is supported by the Netherlands Committees for IAH, ICID, IAHS, IWPCA and IAWQ. The agencies contributing to this meeting are presented at the end of this volume. They are ready to advance further information. This symposium follows after a meeting organised by the IAH, on "Netherlands Hydrogeological Research in International Cooperation" which was held in March 1994 at the IHE. The proceedings of both meetings highlight the work as carried out by Netherlands water experts in projects for international cooperation.

The Organisation Committee:
Joost de Jong (chairman)
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August 1995

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Desiccated nature area "only nature"

Desiccated agricultural area with nature value

Source: provinces, RIZA

Figure 1 Desiccated areas in the Netherlands, 1994

Netherlands Experiences with Integrated Water Management (Proceedings of the meeting in Delft, The Netherlands, 5 October 1995)

DUTCH WATER MANAGEMENT IN PRACTICE, THE REGIWA-PROJECTS: EXPERIENCES, RESULTS, FUTURE DEVELOPMENTS

G. Blom

PREFACE

The name REGIWA-project means REgional Integral WAtermanagement project. In Dutch water management we know these projects as special subsidized projects, that's to say subsidized by the national government, to stimulate "integral water management" at regional level. The Third National Policy Document on Water Management, published in 1989, gave a set of new measures for integral water management: a modern vision on water regarding the use of water systems in relation to the environment. Amongst others provinces and waterboards were meant to put integral water management in practice by carrying out regional projects. To stimulate this, 50% subsidies to pilot-projects were granted. Apart from this, organisational measures were laid down to change waterboards from typical agriculture orientated bodies into all-in organisations.
But let me first tell you about the developments that led us to integral watermanagement and to the REGIWA-projects. After that I shall concentrate on the different types of REGIWA-projects, the conditions for subvention, number of projects in the years 1992-1994, and their results. Finally we can have a look at the lessons we learned and their relevancy for other countries.

1 HISTORICAL DEVELOPMENT TOWARDS INTEGRAL WATER MANAGEMENT

In an average year there is a total inflow of water into the Netherlands of up to 110,500 million m^3; most of this is transported to our country by the river Rhine: 69,000 million m^3. Precipitation has a significant contribution with 30,100 million m^3.

Table 1 Water balance of the Netherlands in an average year [10^6 m^3]

In		**Out**	
Precipitation	30 100	Evapotranspiration	19 500
Rhine (at the border)	69 000	Different uses	5 000
Meuse (at the border)	8 400	River outflow	86 000
Other river inflows	3 000		
	---------- +		---------- +
	110 500		110 500

The inflow of river water and the precipitation can cause high levels of surface water and groundwater in the Dutch delta area, especially in winter time. Apart from this, there is also our ever lasting national combat against the sea. To tackle the problem of wintertime high groundwater levels and the surplus of surface water, the Dutch developed an artificial drainage system consisting of canals, sluices, pumps, ditches, trenches and drains. We have straightened rivers and brooks to enlarge discharge capacity. We can say that up to 1960 water management in the Netherlands was, as a matter of fact, the art of discharging the surplus of water towards the sea. Today this discharging system is very effective. As a consequence we can be confronted with shortage of surface water in dry summer periods. This was the situation in july and august of this year when there was a stop for sprinkling agricultural land because of the low surface water levels in the higher parts of the Netherlands.

The waterworks, built in the south western delta area (Zeeland) and in the Rhine in the sixties and seventies, enabled us to do more with the fresh surface water. Nowadays there are possibilities to store river water in the Lake IJssel and in the south western delta area such that we can transport that water in dry periods to regions with lack of fresh water. The water can be transported, for example, from the Lake IJssel far to the utmost north and east of the country. Water storage and water transport, an effective use of the fresh water for agriculture, shipping, drinking water, cooling purposes, were main topics in the Second National Policy Document on Water Management (1984). We had achieved an economically based effective management of water quantities in which drainage and water supply were the central items.

In the meantime there was also an important development in the field of water quality management. Intensive industrialization and modern intensive agriculture led to severe pollution of surface waters and groundwater. To obtain solutions for the various pollution problems, in relation with water quantity problems, a new water policy was necessary.

We named it integrated water management. It has been laid down in the Third National Policy Document on Water Management (1989). Characteristic for integrated water management is the comprehensive care for the condition and use of water systems, comprising the media water, beds and banks and shores, with their physical, chemical and biological components, in relation to their relevant surroundings. Multi-functional and sustained use are prominent now.

The past five years the national policy of integrated water management has been implemented in provincial regulations and in plans of waterboards. But the real thing is, how to put a new policy in practice, to make it operational, and how to convince local officers of provinces and waterboards. How do you change the minds of local engineers, previously used to focus on the design of water discharge systems, so that they are able to cope with all kinds of problems at the same time: reduction of nutrients, reduction of heavy metals and organic micro-pollutants, heavily polluted sediments, desiccation (man made drought), water distribution, maintenance and recovery of natural banks of streams and waterways. By solving problems in practice, good results are only possible when there is a coherent view on watermanagement, nature and environmental aspects on local level.
There was a strong feeling not to wait too long with putting new methods into practice, because further deterioration of water systems had to be stopped in time. Experience with new technics and also experience with the management of new types of projects by regional authorities and organizations was necessary. That is why the Third National Policy Document on Water Management includes a subvention system to stimulate projects in the field of integral water management. These are called REGIWA-projects: pilot projects to put REgional Integrated WAtermanagement in practice.

2 THE REGIWA-ARRANGEMENT: CONDITIONS, PROJECTS

According to the Third National Policy Document on Water Management there are four types of projects:

- eutrophication combating projects
- desiccation/drought combating projects
- projects to restore or promote nature-friendly banks
- integral water management projects.

Planned and available for subvention were the following amounts of money:
- 1992 18 millions
- 1993 24 millions
- 1994 27 millions of Dutch guilders.

The Ministry of Transport, Public Works and Water Management, but also the Ministries of Environment and Agriculture, Nature and Fisheries, contribute for respectively 60%, 20% and 20% to the costs of this arrangement.

2.1 Financial aspects, numbers of projects

REGIWA started in the year 1992 and ended in december 1994. The subsidies given to the pilot-projects over these years are listed in the table below:

Table 2 Subsidies over the years 1992-1994

year	total subsidies [10^6 guilders]	number of projects
1992	16.3	80
1993	23.2	121
1994	26.9	123

These finances are divided over the various types of projects as shown in table 3:

Table 3 Subsidies over the various types of projects [10^6 Dutch guilders]

type project	1992	1993	1994
eutrophication	4.8	4.3	8.3
desiccation	3.0	5.7	6.3
bank restoration	2.5	5.0	6.0
integral water mgt	6.0	8.2	6.3
Total	16.3	23.2	26.9

In 1991, before the start of the REGIWA-subsidies, 19 desiccation pilot-projects had already been subsidized, for totally 2.2 million guilders. By that time also 6 eutrophication projects had been executed. In 1992 the existing subsidy-arrangements for eutrophication and desiccation projects have been integrated in the REGIWA-arrangements.

2.2 Project characteristics

Eutrophication projects

In case of eutrophication projects the water system, that means the water and the aquatic sediments on the bottom, suffers from a surplus of nutrients. The aquatic biologic system is out of balance: to much algae, much bream and hardly any pike and others predators left. Measures to improve the condition of eutrophic lakes can be removing of the polluted sediments, purification (dephosphatisation) of the water by chemical or biological means, and

making use of water from other places with low nutrient contents, if water inflow is unavoidable and necessary to maintain a certain surface water level. In general eutrophication projects are expensive, costs can mount up to several millions of Dutch guilders per project.

Desiccation or drought combating projects

A major problem of the Dutch countryside is a man-made lowering of the groundwater table resulting in drought damage to nature areas and forests. This drawdown of the groundwater is caused by drainage of agricultural area (60%), groundwater abstractions for drinking water, for industrial water and for sprinkling (30%), increased evapotranspiration due to changes in land use and some other influences. The problem occurs in the whole country but mainly in the higher pleistocene eastern and southern parts of the country. The average lowering of the groundwater table, compared with the situation 40 years ago, is 20 cm, up to 35 cm in highly cultivated areas. Drought is this way, caused by human interference in the hydrological system, leads to a deterioration of the natural vegetation. The map shows the area affected by drought (Figure 1).

There are two types of nature areas: the so called "only nature" areas, 305,000 ha, and agricultural areas with a certain nature value (255,000 ha).
The REGIWA pilot projects aimed to combat desiccation should be situated by preference in areas shown on this map. The following measures for example can be taken:

- putting the drainage system out of order inside the nature area, if necessary also outside
- building small hydrological barriers
- removing, decreasing or stopping groundwater abstractions

In general this type of projects is less expensive. Depending on the size of the area and the measures to be taken costs, vary from ten-thousands of guilders to, in some cases, one or two millions of guilders.

Bank restoration projects

The banks of water systems offer possibilities for development and sustainable functioning of those systems for various uses. So the design of banks is aimed at the functions of the bank, the adjoining water and land. This is important because the rivers (including the flood plains) and canals are the main axes through the Netherlands for transport, recreation, animal-migration and nature.
In the past, bank protection constructions very often consisted of stone or concrete with almost no facilities for animals to settle down there or to move in and out the water. So banks should be more part of the aquatic ecological system in a environment-friendly way. The REGIWA bank restoration projects (nature-friendly banks) aim at the development and construction of typical environmentally and technically bank protections. These projects are ranking from several hundreds thousands to some millions of Dutch guilders.

Integrated watermanagement projects

Finally there are the integrated watermanagement projects: combinations of combating drought and eutrophication, construction of environmental bank protections and maybe also other targets in water management.

2.3 Conditions for subsidizing

In general the REGIWA-subvention is meant for projects carried out by waterboards and provinces. The subvention was possible to a maximum of 50% of the project costs. The aim is to gain experience with procedures and administrative aspects as well as with technical measures in practice.
Only the external costs necessary to realize a project can be subsidized. Not included are:

- costs of land acquisition
- wages/salaries of the provinces' and waterboards' own personal
- permanent costs of exploitation
- normal costs of maintenance
- monitoring (only installation of monitoring equipment can be subsidized).

3 SOME EXAMPLES OF REGIWA-PROJECTS

As examples we can take a drought combating project and an integral water management project.

3.1 Combating drought in the Dwingelder Field

The Dwingelder Field is a moor, situated in the south west of the province of Drenthe. It is recognized as a National Park. However, the Dwingelder Field suffers from man made drought. Since 1990 measures have been taken for nature recovery.

The Dwingelder Field is about 3500 ha peat-moor and bushes, lying between two brooks, the Dwingelder Stream (north) and the Ruiner Stream to the south. Drainage of the surrounding cultivated areas had gone so far (about 1.5 m) that serious damage to natural vegetations occurred. Many species had nearly disappeared. Until 1960 peat has been dug for fuel purposes. To do so, drainage ditches were necessary which also caused further lowering of the groundwater table.

Now there a package of measures has been implemented to combat the drought and to restore nature values. At first the level of the brooklet on the south side has been raised by building a automatically controlled system of weirs. The system is connected with a groundwater monitoring system, adjusted in such an accurate way that the higher levels do not cause to much wet damage to the farmers around. Some pieces of farmland that nevertheless got to wet could be bought and added to the National park. This ingeniously controlled system is expensive: one million guilders.

Secondly, the peat-moor part with existing sphagnum-vegetation in the south east of the nature area, got polluted by nutrients in drainage water from cultivated areas, passing the moor. Now a by-pass for this polluted drainage water has been created. The peat moor has been hydrologically isolated, withholding the original water. Groundwater levels have raised 1.5 m the last years. This gives a new chance for the sphagnum vegetations.
These measures have been combined with the removal of the uppermost toplayer that was polluted with nutrients and even with lead and cadmium (by rainfall). After this has been done, conditions are good enough to ensure the return of the original natural vegetation. Monitoring is going on, but already we can say that this pilot project is very successful.

3.2 Integrated water management: the Ruiten Aa system in Groningen

The Ruiten Aa or Ruiten Stream is a small river, a brook, descending from the Rütenbrocker Moor plateau in Germany. The Ruiten Aa flows meandering northwards through the eastern part of the province of Groningen to the Wadden Sea. To make transport by ship possible a broader and deeper parallel canal has been built. This canal reduced the discharges of the original brook. Since the drainage of the region had to be improved for agricultural purposes, people decided to enlarge the discharge capacity by broadening the brooks' profile and to cut off the original meanders. The brook became a canalized main drain with a discharge capacity of 6 m^3/s.

Recently the province and the regional waterboard identified large desiccated areas in the catchment area of the Ruiten Aa. The river itself was given a ecological function and a aesthetic function in modern water and nature management.
The REGIWA pilot project Ruiten Aa is a combination of drought combating, construction of environmentally sound banks, improvement of water quality and living circumstances for fishes and other animals.
The following measures have been taken:

- Over a great length the river was reconstructed by digging out the old meanders, using old maps to be sure of the right alignment. Digging was possible because the land on both sides of the river was the property of a nature organisation. Here the river was also given environmentally sound banks with high ecological values.
- To combat drought the water level was raised by building weirs. Alongside these weirs fish corridors were constructed to make fish migration possible.
- A sight-seeing point was created for tourists with view over the newly restored river and landscape.

In 1992 the Ruiten Aa got a subsidy of 442,500 Dutch guilders. From a hydrological and ecological point of view this project was successful. Of course it will take time before natural vegetations recover to full extend. Developments are registered by a monitoring system.

4 RESULTS OF REGIWA-PROJECTS

In the years 1992 - 1994 more than 340 projects received REGIWA-subsidy. The total investment of these projects was about 150 million Dutch guilders. All together these subsidies amounted to about 68 million Dutch guilders. All provinces and more than 80%

of the regional waterboards worked with REGIWA-projects, obtained experiences and made good results. We may say that the REGIWA-arrangement has been of great importance.

Most of the pilot projects are situated within the national ecological main structure, as the condition for subsidizing was. The conclusion is that REGIWA-projects made a very positive impact on this ecological main structure.

Preparing projects takes time. During the first year of REGIWA not every regional waterboard or province had possibilities to present projects which were ready for immediate execution. Although one of the conditions for subsidizing was the implementation of measures in practice, during the first year also some research projects received subsidies. Of course these projects would have to be completed in practice in later years.

On the one hand it is a pleasure to note that so short a time after issuing the Third National Policy Document on Water Management in 1989 with its vision on integral watermanagement the new working method was recognized and put into practice by provinces and waterboards on such a large scale. Regional organizations did a tremendous lot of work to prepare projects.
On the other hand it is still a pity that not more projects were initiated. Especially combating desiccation needs many more projects. To local or regional authorities however the preparing of projects - finding finances, going through administrative procedures - is not always very easy. In the recommendations of the REGIWA Evaluation-report, published some months ago, it is stated that:

a. It takes time to get to agreement with all authorities involved, with farmers, land-owners and other participants. In the beginning we were perhaps too optimistic about these procedures. This subject deserves more attention in project planning.
b. Acquisition of ground needed to construct environment-friendly banks appeared to be a bottleneck. Some regulation should be made to facilitate buying ground.
c. In the case of desiccation projects no agreement with farmers could be obtained if there was not an instrument to compensate damage to crops caused by risen ground-water levels.
d. Preparing a project means much personal effort by regional authorities. But manpower is limited and so the number of presented project is.
e. A 50% subsidy is quite a lot, but it is still up to the waterboards or provinces which carry out projects to pay the other 50%. To those authorities, finances are limited too.

About that last remark, finances, I would like to say that regional waterboards, which mostly initiate projects, have their own finances, I mean raising levies. They have the possibility to use those levies to finance projects in order to improve water systems.

5 RECENT DEVELOPMENTS

An evaluation of the water management policy of the Third National Document was published in february 1994. Several measures were added to those that already had been laid down in the Third Document. About the REGIWA-arrangement, ending december 1994, was stated that the impact of the REGIWA pilot projects was satisfactory; no further subsidizing was necessary. An exception was made for the desiccation-combating projects.

The aim of the anti-drought policy is reduction of desiccated area with 25% in the year 2000 compared with the situation of 1985. The way we are proceeding now makes it, however very doubtful we can attain this.
We decided to give drought combating a extra stimulant by issuing a second subsidy regulation, quite similar to the REGIWA arrangement, but now only for drought combating projects. This new arrangement (called GEBEVE-subsidies, in Dutch GEbiedsgerichte BEstrijding VErdroging) started january 1995 and will end december 1999. Every year an amount of 24 million Dutch guilders is available for subsidies, again furnished by the Ministries of Transport Public Works and Water Management, Environment and Agriculture, Nature and Fisheries, each 8 million Dutch guilders per year.

By the end of august 1995 only 13.5 million guilders of the total of 24 million was promised to 70 drought combating projects. So 10.5 million is still available. Reasons for this rather low number of projects are:

- In the REGIWA-arrangement most of the little projects were carried out. Now, having the GEBEVE-arrangement, the bigger projects are left.
- These bigger projects, sometimes cause wet damage to surrounding agricultural land, ask for more deliberation and longer procedures.
- The total amount of available money is 24 million guilders in 1995, more than the REGIWA-arrangement could spend to desiccation projects. Provinces, but mostly waterboards, sometimes hesitate to provide the other 50%, also 24 million.

Research was done last year to a possible arrangement for wet damage: disproportional damage to crops caused by raising groundwater in farmland as a result of drought combating in nature areas. A solution for this problem was suggested, the idea is to capitalize expected damage and to pay out the total amount to the farmers involved at the start of the project (buying off construction). Now the National Government and the Union of waterboards discuss a regulation based on this solution.

6 CONCLUSIONS

From the implementation of integrated water management at regional level the following conclusions can be drawn. They can be of relevancy for other countries too.

1 The REGIWA-arrangement may be regarded as very successful. We succeeded in stimulating integrated water management at regional level. It is really possible to have the theory of integrated water management implemented on a regional scale.

Subvention arrangements like REGIWA and GEBEVE appeared to be good instruments to stimulate developments.
There is a lot of experience now with administrations and procedures. From the technical point of view we are also satisfied, a deeper evaluation on the impact of the hydrological measures will be carried out next year.

2 Not only the REGIWA-pilot projects contributed to the success of integral water management at regional level. New legislation, changes of the Waterboards Act and the Water Management Act, were helpful in this too. Also the adjustment of the waterboards' organisation, I mean the changing of waterboards from typical agricultural orientated bodies into integral thinking organizations is of great importance.

3 Preparing projects required more time than was expected because of long discussions with all participants. So a stimulating arrangement should not be too short but long enough to become effective. On the other hand, subsidy arrangements always should be short enough to ensure progress within reasonable time.

4 Regional authorities and local inhabitants should get used to the system that the finances for projects to improve regional or local water systems are furnished by the people in that region. It is possible to raise a general levy for all persons inside the waterboard's boundaries. Today these personal levies of waterboards are rather new. Waterboards sometimes hesitate to raise levies. I hope that after some time a balance is found and levies are just enough to finance integral water management projects.

5 A last remark: to obtain good solutions for water management problems, especially with bigger projects, measures in the field of (integral) water management should be taken in combination with physical planning. This inter-action between water management and physical planning will be elaborated in more detail in our Fourth National Policy Document on Water Management, to be issued in 1997.

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Netherlands Experiences with Integrated Water Management (Proceedings of the meeting in Delft, The Netherlands, 5 October 1995)

ADAPTING CAPACITY OF INSTITUTIONS, A PRECONDITION FOR SUSTAINABLE WATER MANAGEMENT

P. Huisman & J. de Jong

INTRODUCTION

Capacity building consists of two elements, capacity and building. Capacity concerns the ability of a society to respond adequately to changing conditions. Capacity building is the process of gaining technical, managerial and institutional knowledge and insight in relation to the socio-economic structure, cultural standards and values of the society concerned. It aims to increase the flexibility of institutions and the society to adapt to the changing circumstances. This contribution describes the adaptation of The Netherlands' society and institutions in the course of time with respect to water management.

Modern integrated water management defines three basic elements: the natural, the socio-economic and the institutional system (Wisserhof, 1994). The basic elements can be distinguished having different accents in every period of the systematic cultivation of The Netherlands since 1000 AD. Before 1000 the inhabitants were living on high river banks or self raised dwelling mounds. In the beginning of the cultivation period people considered the natural system as unchangeable. Self created institutions promoted the water related interests on local and regional scale. These interests were flood protection and drainage for living and agriculture. Later military defence and inland navigation became also subject of promotion. In the twentieth century the promotion of interests by the water management institutions increased to a large variety of human and nature related activities. This contribution shows the process of capacity building by the local society from the past to the present institutional system for flood protection and water management. It also describes the international arrangements for the management of transboundary river basins and the North Sea. This represents another important aspect of capacity building. The adaptive capacity of the institutional structure on national and to a certain extent on international level has proved to be a prerequisite for integrated water management.

1 FROM PROMOTION OF LOCAL INTERESTS TOWARDS WATER MANAGEMENT ON A NATIONAL SCALE

1.1 From local to regional water management

As known from history the Romans undertook the first large-scale interventions in the natural conditions in this country. The systematic cultivation of The Netherlands took place since 1000 AD. The interventions were small and their impacts limited to the immediate surroundings. It started with small-scale promotion of flood protection and drainage for human settlements and agricultural activities. Initially the local society exercised the supervision on the flood and drainage activities. Evidently, because these undertakings were of common interest to survive. Later it became impossible for the local society to exercise directly the supervision on control and maintenance. The closure of the tidal creeks and inlet and the connections between the local flood protection and drainage systems enlarged the number of local societies depending on these common activities. From that time, the thirteenth century, the local society began to designate representatives to regional meetings. In these meetings the representatives discussed the promotion of the common interests, e.g. the control, maintenance and financing of drainage systems, dikes, dams and sluices. The base to finance the common activities consisted of a simple rule: the extent of the property defines the levy to be paid for the agreed activities. Consequently, the right of say in these meetings was proportional to property and payment of levy. The rulers in the country soon recognised this democratic form of self-organisation. In course of time rulers came and disappeared but this form of self-organisation remained. It is capacity building by the inhabitants themselves (Ven, 1993).

1.2 Necessity of centralisation

The Hapsburgs who ruled this country since the fourteenth century attempted to centralise the Government. In 1581 this country became the Republic of the Seven United States of The Netherlands. The common issues of this republic were defence and foreign politics. In other affairs the States composing this republic acted sovereignly. This situation proved to be disastrous for the super-regional water management. Often States worsened the conditions for a safe discharge of water and ice in the main rivers by activities limiting the discharge capacity. It took centuries to decide upon some river improvement works. Early 1700 four States decided to improve the bifurcations of the Rhine. Realization took years. It came to a climax in 1707, when opposing cities destroyed common agreed measures to improve the bifurcation of the Rhine at Pannerden. These cities feared for their navigation interests (Ven, 1993).

After the French revolution in 1795, the institutions in The Netherlands received a more centralized structure. In 1798 the Government decided to create a national agency competent for all super-regional water management affairs. This national agency, Rijkswaterstaat, an untranslatable name in foreign languages, started its activities by decreeing a warning system and competence regulation applicable during dangerous periods caused by floods and ice jams. The agency began to collect all kinds of data about inland and coastal waters. Based on these data the Rijkswaterstaat undertook river

corrections, construction of canals and reclamation activities. In time it required a broad knowledge in technical, managerial and institutional matters.

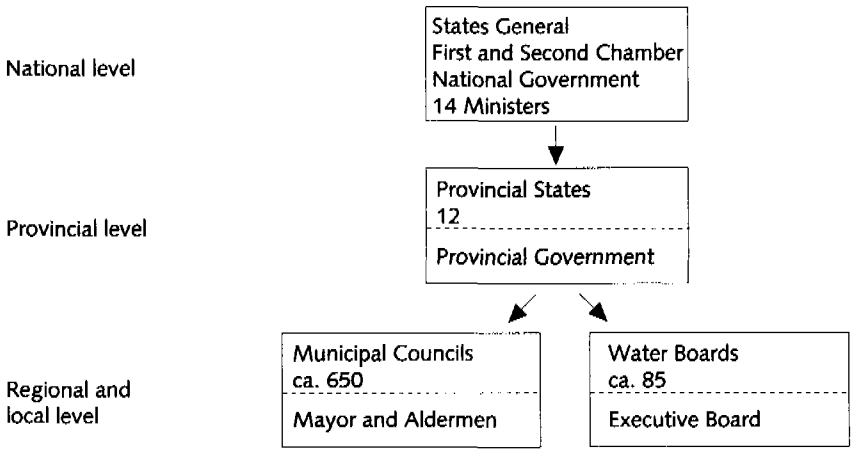


Figure 1 Constitutional structure of The Netherlands

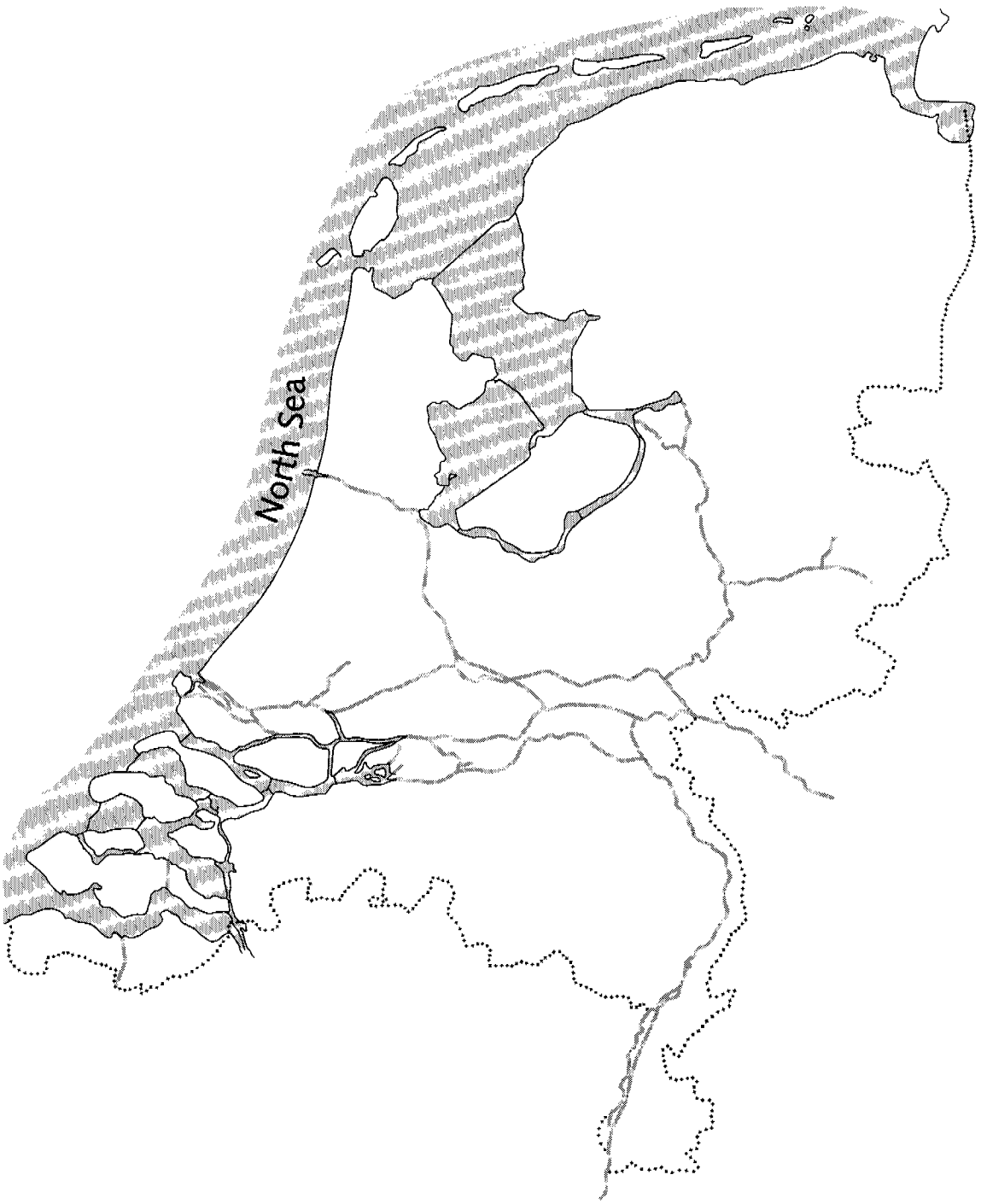


Figure 2 State managed waters in The Netherlands

1.3 The decentralized unitary state after 1848

In 1848 the institutional character of The Netherlands changed. The modification concerned the dualistic responsibility of the king as head of state on one hand and the national Government and Parliament on the other hand. The Government and Parliament have the overall responsibility. From 1848 on the national Government defines the main lines of the national policy under approval of the two chambers of Parliament.
The twelve provincial Governments must apply and translate the main lines to their regional situation. Provincial Governments have a great manoeuvring space. Exceptionally the national Government decides to interfere in regional and local issues. Interventions only take place when national interests play an important role. By absence of a national policy about imposing issues, the provincial Government and Parliament are fully competent to regulate these issues.
In line with the Constitution the province has the supervision over municipalities and water boards. The province has the competency to formulate the tasks, organization and financing of the water boards within its territory. Figure 1 gives the institutional structure of The Netherlands.

There are several authorities exercising their competencies for flood control and water management. The national Government is directly responsible for some main dikes and closing dams, the main rivers, some super-regional shipping canals, the Lake IJssel, the Delta waters and the sea. Figure 2 represents these state managed waters. The Rijkswaterstaat is the competent national authority for these waters. The policy of the local and regional water management is a constitutional task of the provinces under approval of the national Government.

In the beginning of this century the growing population required a higher food production. The increasing export also demanded more agricultural products. To fulfil the requirements, individuals and associations developed plans for new polders in the Zuyder Sea. Closure of this inland sea would create appropriate conditions to realize new polders and improve the water management in the whole northern part of The Netherlands.
The storm surge disaster of 1916 gave the final push to dam off the Zuyder Sea. The main dam created the Lake IJssel in 1932. The fresh water of this lake supplies the new polders and the northern areas and is also a source for drinking water production.

After the storm surge disaster in 1953 Government and Parliament decided to execute the Deltaplan. The closure of the estuaries created the possibility of a fresh water reservoir in the southwest of The Netherlands. Because of that reservoir there is enough water in this part of the country for general water supply and to fight the salt water intrusion via the Rotterdam Waterway. It proved to be possible to deviate water to the North even during low water periods of Rhine and Meuse. The canalization of the Lower Rhine served this objective.

Meanwhile the necessity of distribution rules arose. For what purpose and under what conditions should water be deviated to the north or be used in the western areas. The First national policy document on water formulated the distribution rules in 1968. This

document considered the quantitative aspects of the water management only. It also indicated possibilities to intensify the water management on the national level; large hydraulic works were planned. The fight against the increasing pollution of the surface waters followed a separate track, although the national agency, Rijkswaterstaat, was also responsible for the water quality aspect. An integrated approach of water problems failed at that time.

1.4 Mobilisation of population: fight against pollution

Since the twenties of this century the central Government tried to convince municipalities and water boards about the necessity to build sewerage systems and to treat waste water. Sewerage systems collecting waste water were accepted more easily than treatment of waste water. Only a few authorities became convinced of the necessity of waste water treatment.

After the Second World War the waste of population and industry grew to such an extent that the self-purification capacity of the surface water became overstrained. This led to oxygen depletion. The water in ditches, canals and rivers began to stink. It led to unhygienic conditions in urban areas. It also hampered the interests of recreation and nature. The population became aware of the deteriorating conditions and pressed the authorities to act. The first environmental law in The Netherlands became the Act of 1970 to protect the surface water against pollution. This act was beneficial to population and environment. The discharge of oxygen consuming substances to the surface water amounted to forty million inhabitants equivalents (i.e.) in 1970. Twenty years later the discharge of these substances was reduced to seven million i.e. Simultaneously the treatment capacity increased from six million i.e. to thirty-six million i.e. Without support of the population this improvement would not have been realised. The yearly cost to collect and treat waste water rose from 0 guilders in 1970 to 350 guilders per household today.

1.5 Controversies about the Deltaplan

After the disaster of 1953 flood protection and fight against salinisation received priority. At the end of the sixties and the beginning of the seventies the ecological movement began to oppose against the Deltaplan because of the impact on the environment. The clean salty environment of the Eastern Scheldt would be changed in a stagnant fresh water lake fed with the dirty Rhine water. The opposition against the Deltaplan had supporters in Parliament and Government. The Government nearly fell because of the controversies. Finally the Government decided to reconsider objectives and measures. Rijkswaterstaat, Delft Hydraulics and the American Rand Corporation did the necessary research.

For the first time the tool of policy analysis was applied in The Netherlands. The study concentrated on three alternative solutions: heightening the existing dikes along the estuary, a dam or a storm surge barrier, to be closed under extreme conditions. Finally the choice was an open Eastern Scheldt temporarily closed by a storm surge barrier. It meant a rupture with the traditional trend in The Netherlands' history. Water management

was no longer exercised for human related interests. Since then nature related interests received more attention and weight in the decision making process. From these controversies we learned that changing views, understanding of different feelings and mutual respect of running opinions are essential elements to formulate sustainable objectives. We also learned that large scale works of which realisation takes decades need periodical evaluation. It is necessary to evaluate if the original objective is still being met or has to be adapted to changed circumstances. This also requires a flexible structure of the plan and an adaptive capacity of the institutions.

1.6 New institutional arrangements for the water boards

In 1953 The Netherlands had some 2500 water boards. Only some of the older water boards had a large territory and powerfully exercised their competencies. Most water boards were small because of that great number. Consequently, the executive body of most of the water boards was not powerful. The knowledge of the technical and administrative staff was low. The small scale of the water boards has contributed to the extent of the disaster of 1953. In the sixties and the seventies heated discussions about the water boards took place. Some political parties wanted to abolish this form of functional Government, others were in favour of reforming the institution of the water board.

In the middle of the seventies Government and Parliament decided to reform the institution by scaling up their activities and governing power. The responsibility for waste water treatment and for the water quality in local and regional waters became the duty of the water boards. Today The Netherlands count some eighty water boards, a decrease with a factor thirty in four decades. The process of integration of flood protection, quantitative and qualitative water management tasks is still going on. Finally some sixty water boards will remain. The lesson from this development is that the reform of an old institution, once the democratic backbone of flood protection and water management, is better than its abolishment because of its deep rooting in the society.

1.7 Rational use of water

The First national policy document on water of 1968 contained the large scale works to fulfil every need of water in every region in The Netherlands at almost every time. The Rijkswaterstaat was in charge to carry out these works. The water boards should implement the local and regional works for water supply. The plans failed a solid analysis of benefits and cost. The year 1976 was exceptionally dry. The Netherlands became aware that a policy on rational use of water was necessary. This led to the PAWN-study (Policy Analysis of Water in The Netherlands) realised by Rijkswaterstaat, Delft Hydraulics and the American Rand Corporation. The research institutes studied the quantitative aspects of ground water and surface water according to a coherent approach.

The study showed that the planned large scale works were unrealistic; small works in some regions could meet the demands. The PAWN-study provided the base to define the main water management system and the regional systems. It supported the development of better plans to distribute the available water over regions and interests. The improved

insight formed the backbone of the Second policy document on water of 1985. Moreover this policy document showed the necessity of a water management act. It also contained the starting points to reform the water management structure in The Netherlands (cf. the paragraph about the new arrangements for the water boards).

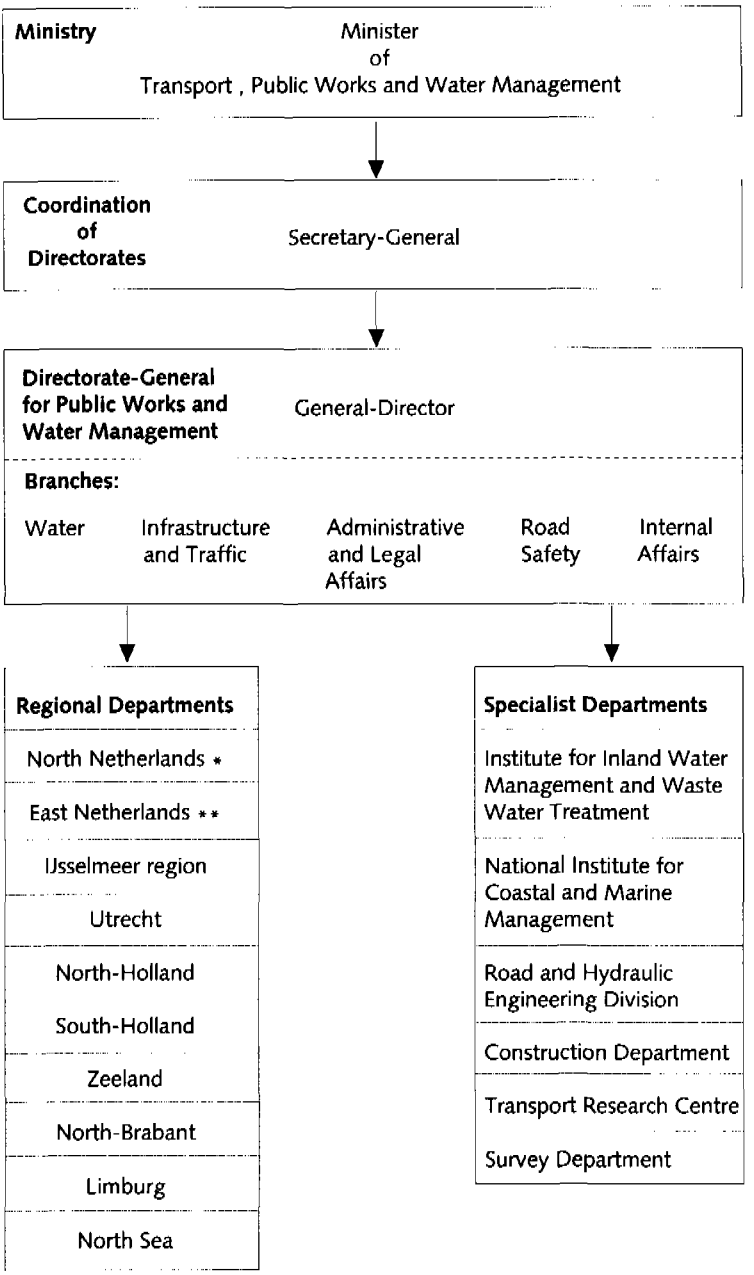
1.8 Reorganisation of the Rijkswaterstaat

The organisational structure of the national agency Rijkswaterstaat, part of the Ministry of Transport, Public Works and Water management, dated from the nineteenth century. The core-business of this agency was and still is the national responsibility for flood control and water management, road and navigational infrastructure. The agency also directly controls the main water management system, closure dams and barriers, the national highways and weirs and locks in the main shipping routes. In the seventies the agency consisted of a chief directorate, 15 regional directorates and 9 research institutes.

The first reorganisation concerned the regional directorates. They had a complex structure with a small head office, some strong arrondissements and several cantons. Some directorates had research branches dealing with the same questions as the scientific institutes of the Rijkswaterstaat. The organisation of the water related research institutes was orientated either to water quantity or to water quality. The mutual cooperation between the institutions and the research branches of the regional directorates was not very strong.

In 1972 the top of the agency decided to reorganise the regional directorates. The main office and the arrondissements got an integrated and functional structure. Divisions for water management, traffic and transport, realisation of new infrastructure, administrative and legal affairs formed the new structure. The cantons disappeared and split up in water related and road related districts. The research branches became part of new divisions of the central research institutes.

During decades the Delta-Directorate adsorbed many Rijkswaterstaat members. It also employed many researchers, designers, constructors and managerial staff. The realisation of the Deltaworks would end in the eighties. The Rijkswaterstaat had to integrate this directorate into its organisation. Discussions about the desired water management structure for the research institutes took place in the same period. The top of the agency and the middle management of the institutes became more and more convinced that water quantity and water quality questions could not be separately dealt with. After the first round to reduce the pollution, it became clear that hydraulic measures influence the quality of the water system; e.g. weirs do settle (contaminated) sediment. On the other hand emissions can also affect the availability of water quantity or navigation depth because of the polluted sediment. The integrated approach of water quantity and quality is also a must.



* Groningen, Friesland and Drenthe
** Overijssel and Gelderland

Figure 3 Structure of the Directorate-General for Public Works and Water Management

To avoid research institutes with more than 1000 staff members, the top of the Rijkswaterstaat decided to divide the tasks along the line of fresh and salt water systems. The changed conditions are the base for this decision. Since the realisation of the Deltaworks the Rotterdam Waterway is the only direct connection between salt sea water and fresh river water. This is the reason that the Rijkswaterstaat created the National Institute for Coastal and Marine Management and the Institute for Inland Water Management and Waste Water Treatment. Figure 3 gives the present organigram of this agency.

1.9 Internal and external integration of structure

In the Second policy document on water the coherence between ground water and surface water became very obvious. Convinced about the integration of water quantity and water quality and the need to harmonise the water related interests with the environment, the Rijkswaterstaat wrote the document "Living with water" in 1985. This document is a continuing plea for integrated water management. Internal integration means integration of water quantity, water quality, ground water and surface water. External integration aims at harmonisation of the water management aspects with the policies on physical planning, environment and nature.
The leading principle of "Living with water" is preservation and rehabilitation of water systems. Major objective is the harmonisation of human and nature oriented demands without harmful impacts. Later this leading thought proved to be part of the concept of sustainable development as formulated by the Brundtland Commission.

In 1989 the national Government published the Third policy document on water along the lines described above. The main objectives of that document are: a safe and habitable country and healthy water systems which guarantee sustainable use.
The external harmonisation was given a special accent. The Netherlands' Government presented the Third policy document on water together with the policy documents on physical planning, environment and nature to Parliament. Integrated water management is a must and has to be intensified.
Provinces and water boards have set up and implemented the different elements of the policy documents mentioned. Integration and harmonisation are key-issues for provincial planning. Evaluation of national, provincial and regional policy is now under way.

2 INTERNATIONALISATION OF THE WATER MANAGEMENT

2.1 Sectoral interests predominate the first steps

In history the first major common interest of the riparian Rhine States proved to be navigation. The rulers along the Rhine liked to profit from the main traffic artery in Western-Europe. Numerous were the tolls along the Rhine where the passing ships had to pay duties to the rulers of the different Rhine stretches. The European States discussed the necessity of free navigation on the Rhine in Vienna in 1815. They decided to establish a Central Commission for the Rhine navigation (CCR) based on the principle of free navigation. The Central Commission for the Rhine navigation, the oldest, still vital,

international organisation in the world has undertaken and undertakes many improvements and still measures beneficial for the shipping.

Another important common aspect was the fishery. In former days the supply of fish to the markets along the Rhine was rich; especially the salmon supply. Weirs and dams for navigation and hydro power became obstacles for the salmon and other migratory fish. The migratory fish could not pass these obstacles. The high water levels produced by the weirs affected the specific physio-biological conditions for the fish. After 1913 there only remained some spawning-grounds in the Upper Rhine and in the Moselle. Later on these areas also disappeared by canalization works.
Strong one-sided promotion of some interests can eliminate other interests. Mitigating measures to ensure sustainable conditions for the affected interests are indispensable.

2.2 Pollution of the Rhine, threat from upstream

Until the turn of the century, the quality of the water provided by the Rhine and Meuse to The Netherlands was good. Industrialisation and rapid growth of the population began to make excessive demands on the self purification capacity of the river. Organic and inorganic impurities were a growing problem. A good example is the rise in the chloride content of the Rhine. In 1932 the Netherlands' Government already made observations to Germany and France about the danger which the salt content of the Rhine imposed on the country's water supply. Having solved the problem of salt intrusion from the North Sea, The Netherlands now saw itself threatened with the same problem, this time from its European hinterland.

After the Second World War again the Dutch Government addressed to the other Rhine States. The consultations between the Governments of the riparian States led to the creation in 1950 of the International Commission for the protection of the Rhine against pollution (IRC). It marks the first step towards the internationalisation of the water management. In 1963 the IRC got its legal base according to international law. The IRC started to set up a monitoring system and studies to identify the different types of pollution and their impacts. These elements form the necessary base for deliberations and negotiations. But it proved to be impossible to take common steps to reduce the pollution.

By the late sixties and early seventies, the relentless increase of organic polluting substances in the Rhine had led to a serious deterioration in the oxygen balance. The sharp rise in discharges of harmful chemicals, nutrients, heavy metals and heat worsened the situation. The problems of the Rhine came to a climax in the autumn of 1971. Large quantities of waste water and poisoning accidents hindered the use of water; intake for drinking water production stopped. Aquatic life disappeared in the lower part of the river. Press and public opinion began to designate the Rhine as the open sewer of Europe. They recognized the gravity of the situation and brought pressure on the authorities to take corrective measures.

This led to the first conference of the ministers for the environment of the riparian Rhine States in The Hague in 1972. The ministers instructed the IRC to draw up conventions against the chemical and chloride pollution, and a long-term working programme.
In 1976 the ministers signed the conventions against the chemical and chloride pollution. They also approved the long term work programme concerning the waste water treatment in the Rhine basin. It marks the first international commitments to reduce the pollution of the river.
Since 1972 the ministers of the Rhine States met eleven times. The ministerial conferences have strongly supported the Commission's work. The IRC could ask the ministers to decide about options and problems for which within the Commission no decisions could be reached.

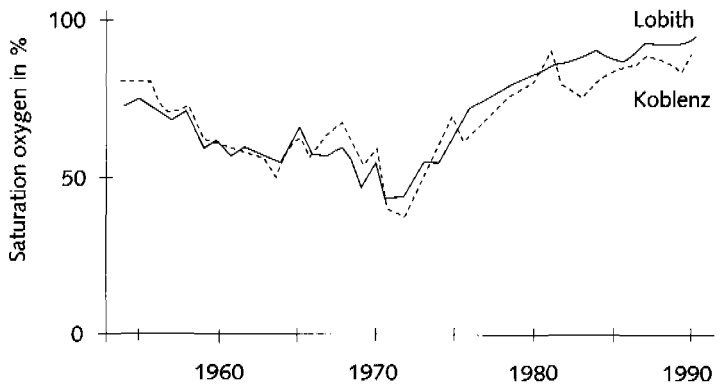


Figure 4 Oxygen content of the Rhine at Koblenz and Lobith

Figure 4 shows how, after the water quality of the Rhine had reached an all-time low in 1971, the efforts of the riparian States led to a gradual reduction in the volume of pollutants. Life returned to the river, and its water could be used again.

2.3 Contaminated sediment, a lasting threat for the environment

The water quality improvement did not solve all problems. The rivers are depositing sand and silt in the Delta, in the ports of Rotterdam and in the North Sea. In earlier centuries, silt and sand dredged from these waters were in great demand for use as a fertiliser and for raising the level of the land.
The situation radically changed since the end of the seventies. Micro-pollutants attaching to particles suspended in the water threatened the quality of the sediment. High concentrations of heavy metals and organic (micro)pollutants were found to be present in the gardens of new housing estates that had been built on dredged soil. Agricultural land proved to be contaminated by mud that had been deposited on it. Vegetables contained unacceptably high concentrations of dangerous substances. The high PCB contents of the Rhine and Meuse also meant that the sale of eels caught in those rivers' sedimentation areas had to be banned.

Contaminated sediment with high concentrations of dangerous substances has to be considered as chemical waste. Therefore contaminated mud either had to be stored at controlled dump sites, or, as a last resort, had be left where it was. The Netherlands' Government decided that only slightly polluted sediment may be dumped at sea, since heavily polluted materials could have irreversible consequences in later years.

That is the reason, why the Government has created a large dump site before the Netherlands' coast. Here the dredging spoil from the Rotterdam port entrances is stored. The cost is very high, \$ 2/m^3. The quantity to be stored yearly amounts to 10 to 15 millions m^3. The storage capacity of the dump site ends in the year 2000. This measure created much international understanding and confidence about the environmental intentions of The Netherlands. In turn The Netherlands demanded that around the year 2000 the sediment quality should have improved in such a way that the sediment can be dumped in sea or applied on land.

Focusing on the international aspects of this type of water pollution, it has to be mentioned that 95% of the heavy metal load in Netherlands' waterways enters the country by the transboundary rivers. When they flow to the North Sea, not all suspended particles settle immediately. Marine currents pick up many of them and transport them northwards, where a large part of them settles in the Wadden Sea or German Bight (Figure 5). In the German Bight a shortage of oxygen occurred in the eighties. It resulted in dying of bottom animals on a large scale. In 1988, more to the north, algae bloom caused considerable mortality of fish. In 1990 mortality of seals on a large scale occurred.

The problem of pollution does not only concern The Netherlands, but every country bordering the North Sea. Faced with these problems, the working method of the International Rhine Commission has been applied to the North Sea basin. In 1984 the North Sea States came together in the Federal Republic of Germany to discuss the problems and to take the first steps to reduce the pollution of the North Sea.

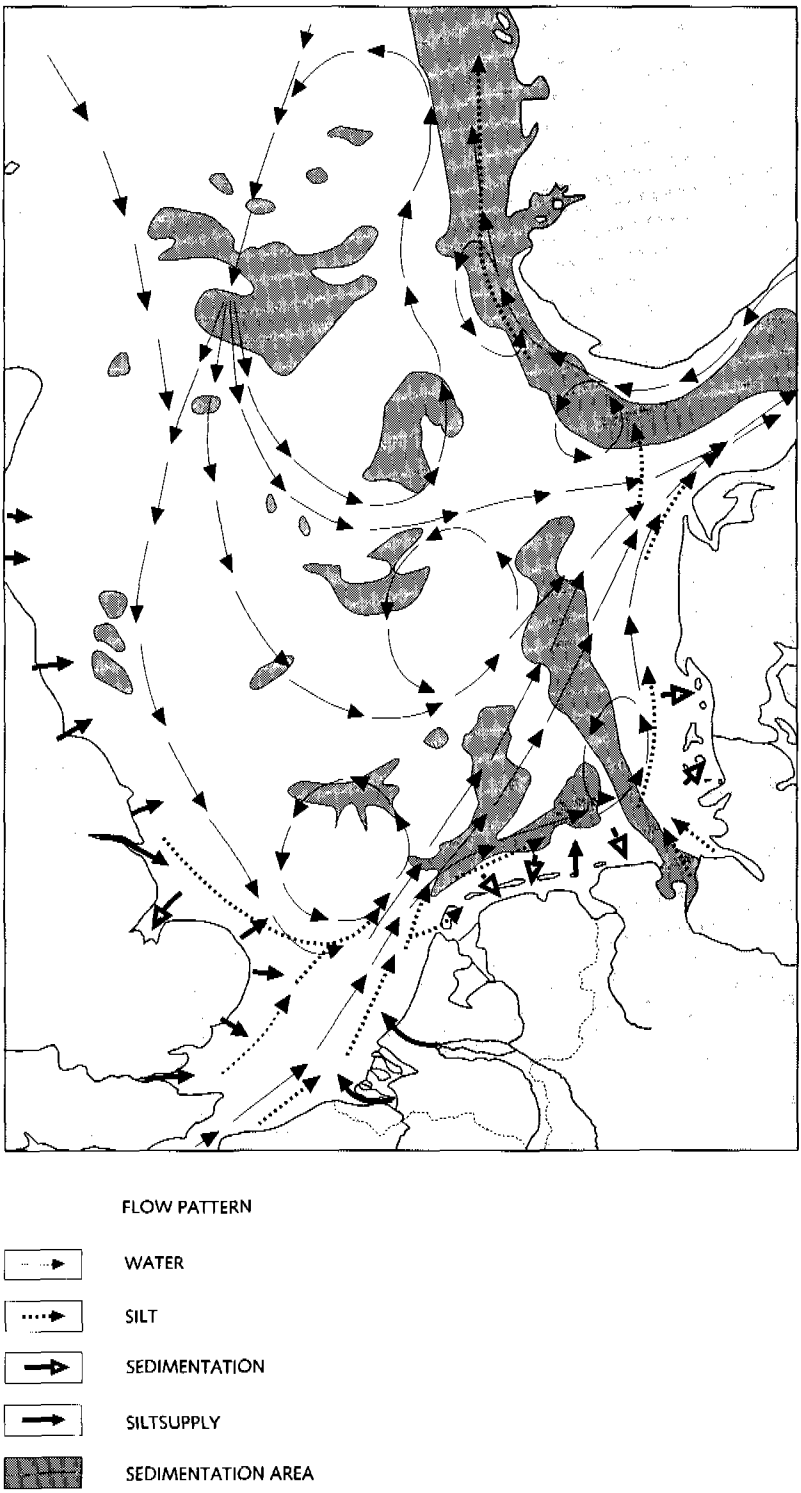


Figure 5 Water and sediment movements in the North Sea

2.4 Fire in Basle, occasion for an integrated commitment

The store facilities of Sandoz, a chemical enterprise in Basle, set fire in 1986. The fire-fighting water became heavily contaminated by insecticides. The poisoned water was released into the Rhine. The poison wave propagated downstream the river killing all organisms over a long stretch of the river. The other riparian States did not blame Switzerland. This country was the first Rhine state treating all waste water. The disaster led to several meetings of the Rhine ministers in 1986. Besides measures to prevent accidents like the Sandoz-event, the ministers adopted new long term objectives for the Rhine:

1 higher species as migratory fish should return to the Rhine in or before 2000. The symbol for that objective is the salmon, the best known specimen

2 future use of Rhine water for public water supply must be possible with simple production methods

3 the pollution of sediments has to be reduced to such a low level that sediment can be applied on the land or dumped into the sea without affecting consequences for aquatic organisms.

In the "Rhine Action Plan" (RAP) the IRC presented proposals to fulfil these objectives, cf. the IRC-activity-report of 1987. The adoption of RAP by the ministers in 1987 implies an integrated commitment of the riparian Rhine States to a further reduction of the pollution and to an improvement of the ecosystem of the Rhine. Later on the ministers added a fourth point, the harmonization with the "North Sea Action Plan". It led to a sharpening of the RAP for some targets.

2.5 Modified approach for further reduction of the Rhine pollution

Instead of continuing the detailed elaboration of emission standards prescribed by the chemical convention, the Rhine ministers adopted the IRC-proposal to reduce the pollution by selected substances by 50% during the period 1985-1995. This decision allows the riparian States to define the most effective way to realize this goal on their territory. It implies that not only point sources but also diffuse sources from households, agriculture and traffic etc can be tackled. This approach paid off. In recent years phosphate containing detergents disappeared and PAH's containing wooden products considerably diminished.

The States bordering the North Sea adopted the IRC-approach in 1990. They amended some IRC-proposals in the light of ecological impacts on the North Sea. The minsters of the North Sea States sharpened the objective of 50% reduction to 70% for mercury, cadmium, lead and dioxin.

2.6 Further rehabilitation of the Rhine ecosystem

An integrated approach is necessary to meet the aimed presence of migratory fish species like the salmon in the Rhine. The IRC worked out this approach in its master plan "Salmon 2000", published in 1991. This plan concentrates on two issues:

1 rehabilitation of the main stream and tributaries as backbone of the ecosystem for the migratory fish

2 protection, preservation and restructuring of ecologically important Rhine reaches.

Priority must be given to the access to and the rehabilitation of the spawning grounds to meet the first issue. The IRC-investigations indicates that 250 ha along the Rhine and some tributaries can be restored as nursery for the migratory fish. Spawning areas have to be accessible for the fish. For that reason the present dams and weirs must be equipped with proper provisions allowing the fish to surmount these obstacles. The riparian Rhine States are providing the weirs with fish passages to realize the migration and spawning. The Netherlands adapted the water-release-regime of the sluices in the former Zuyder Sea and Deltaplan barriers to the migration demands.

Administrative-legal provisions must create the conditions to meet the second issue. Particularly the reaches Constance/Basle, Karlsruhe/Mayence and Duisburg/Nijmegen/ Arnhem should be assigned as wetlands submitted to the regulations of the Ramsar Convention. These reaches are the stepping stones for the rehabilitation of the ecosystem of the Rhine. The master plan envisages an extension of the stepping stones. All applications for land use along the Rhine and its valley must be subjected to an environmental audit to prevent further degradation of the ecosystem.

In March 1993 an international conference, devoted to the rehabilitation research of the river Rhine, took place. Researchers found a remarkable improvement of the river water and the biological composition over the last two decades. This conference established progress in the number of autochthonal species inhabiting the river. In 1990 the first restoration of spawning areas in one of the tributary resulted in the catch of several salmons. Nowadays sea trouts are common upstream of the weirs in the Upper Rhine. Dutch fishermen recently caught young sturgeons.

2.7 The 1995 river flood stimulates the mutual cooperation

The ministers of the Rhine States charged the IRC to develop plans to rehabilitate the Rhine ecosystem. Remarkable, because the Rhine States particularly created this institution to fight the pollution of the Rhine. It were steps to integration. The integration and harmonisation process is still going on. The flood problems in January/February 1995 brought a further step. The ministers of the riparian States declared in Arles, France that measures have to be taken to reduce the future risks posed by high water levels in Rhine and Meuse.

They are convinced that concrete measures must be taken in several fields. The ministers ask special attention for spatial planning, land use and water management. They particularly stressed the spatial planning per river basin. Land use signifies the impact of agriculture, forestry, nature management, urbanisation and recreation on the run off. Water management concentrates on buffer zones, dikes and embankments, and flow management.

To expedite matters, the minsters decided to make maximum use of existing structures and research institutes. In line with this starting point they charged the IRC to develop a flood prevention plan. The ministers want a similar approach for that plan as applied for the RAP for the reduction of the pollution and rehabilitation of the ecosystem. For the Meuse the plan of action should follow the steps of the IRC.

The developments in the last decade illustrate the truth of the title of this contribution. The adaptive capacity of the institutions (national and international) is a prerequisite for sustainable water management.

3 CONSIDERATIONS FOR CAPACITY BUILDING ABROAD

The main objective of this symposium concentrates on the lessons, that can be learned from the countries in Northwestern Europe in view of capacity building in other (developing) countries. It is a very difficult question because capacity building looks like a capital but it behaves like circulating money. The more this capital is being spent, the more output is yielded. Practice makes perfect. Creating appropriate conditions stimulates the capacity building of the participating institutions and representatives of the different interest groups. Attention should be paid to the following specific elements:

- Open-minded, understanding of different feelings, respect for other opinions and confidence in negotiation partners are fundamental elements to formulate sustainable objectives on all levels. Therefore create and stimulate open communication, participation and decision making that is easy to verify. These are essential items to achieve support for decisions.

- Develop long term views, particularly in the institutions, about the problems in the natural, the socio-economic and the institutional systems. Be aware of the impact of differences in cultural standards and values.

- Give the administrative and legal system a clear structure. The competencies on federal, national, regional and local level must be clear for institutions, interest groups and citizens. Be aware and recognize the formal and informal network of the administrative and legal systems. These elements are the starting points for adaptations.

- Stimulate self organisation of the involved interests. It creates a platform to bundle and articulate views and feelings about the different issues. One gets competent discussion partners in the decision making process.

- All measures to avoid and to fight water pollution should be financed according to the principle: the polluter pays. Local and regional measures in the fields of flood control, drainage and water supply should be paid by the local or regional society according to the profit principle. It provides the basic condition for good management and maintenance of water systems, including its hydraulic works and organization.

- Data collection of the natural resource systems and impact data of human interventions provide an appropriate base for decision making in water management. Transparent aggregation of available data into effective information supports the formulation of concrete actions.

- Problems should be updated and evaluated periodically to adapt existing plans and to formulate new programmes. Organise the planning not only for water management but also on adjacent policy fields. Alternative top-down and bottom-up planning stimulates the adapting process.

ACKNOWLEDGEMENT

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CAPACITY BUILDING AND WATER RESOURCES MANAGEMENT IN YEMEN: THE WRAY PROJECT EXPERIENCE

A.J.H. Negenman

ABSTRACT

Yemen is in a water crisis. One of the most serious problems is the rapid depletion of the groundwater resources, which will have dramatic socio-economic consequences.
The Water Resources Assessment Yemen project was started in 1982 to build up local capacity in water resources assessment and water-related information management. During the sequel project phases the counterpart organization of the project, the General Department of Hydrogeology, evolved from a relatively small group of university graduates into a well trained group of professionals within a well structured and managed organization. This organization is able to provide high quality services to the Yemeni water sector and third parties.
The technical activities of the project in Sadah, Wadi Surdud, Wadi Adhanah-Marib and Abyan Delta, and the national review of information contributed significantly to the increase in knowledge about the water resources systems in Yemen. From the onset the project considered the process of execution of the technical activities to be as important as the technical deliverables. On-the-job training in the water resources studies executed in different areas in Yemen was found to be one of the most important and effective methods for developing human resources.
Using the concept of the water policy life cycle, the current phase of the water policy in Yemen can be identified. During the WRAY projects the water policy in Yemen was mainly in a problem recognition phase, although a number of activities related to policy formulation had been undertaken in the eighties. Now, the organizational and regulatory arrangements that govern water resources management in Yemen are moving towards the next phase in the water policy life cycle: policy formulation. A National Water Resources Authority has recently been established based on the General Department of Hydrogeology and the Technical Secretariat of the High Water Council.

1 INTRODUCTION

Yemen is in a water crisis. It has one of the lowest per capita recharges of groundwater resources in the world. Very few other countries have such severe depletion of the groundwater resources. Almost all the surface water in Yemen is being used for agriculture and little water reaches the sea. Approximately 90% percent of the groundwater abstracted is used to irrigate crops.

If adequate water resources management is not introduced soon, at least in the socio-economic important areas of the intermontane plains, large capital destruction and loss of future potential will occur in the urban construction and rural irrigation sectors because it will no longer be possible to supply water at affordable costs.

The Yemeni government and the External Supporting Agencies (ESA's) have long been aware of the need for water resources assessment and water-related information management in Yemen as basis for water resources planning. In 1982 a bilateral cooperation project, involving the governments of Yemen and The Netherlands was launched, with the general aim of contributing to adequate water resources use and management. Two specific objectives were defined in this Water Resources Assessment Yemen (WRAY) project: to promote the technical and the managerial self-reliance of the General Department of Hydrogeology (GDH), and to increase the knowledge on the water resources of Yemen.
The TNO Institute of Applied Geoscience was responsible for The Netherlands' implementation of the project.

This paper describes the changes that occurred during the sequel WRAY project phases in three elements that were integral to the project until its conclusion in March 1995. These three elements are:

1 the General Department of Hydrogeology
2 the knowledge of the water resources systems
3 the water policy life cycle in Yemen.

Thanks to its specific approach the WRAY project contributed significantly to the changes that have occurred, although it must be noted that many other factors which were beyond the control of the project or competent authorities also contributed (positively or negatively) to these changes.

2 EVOLUTION OF THE GENERAL DEPARTMENT OF HYDROGEOLOGY

The General Department of Hydrogeology (GDH), one of the general departments of the Mineral Exploration Board (MEB) in the Ministry of Oil and Mineral Resources (MOMR) in Yemen was established in 1978 by Governmental Decree. The MEB has a Chairman with the rank of Deputy Minister. The GDH is managed by a General Director (GD).

The mandate of the GDH states that it is responsible for the nation-wide collection of water-related data and for the investigation of the water resources in the country.

The General Department, known as the Department of Hydrogeology (DOH) until the late 1970's, initially received assistance from USAID. This aid consisted mainly of giving university graduates further training in theory; they had virtually no practical experience.

At the start of the first WRAY project phase in 1982 the GDH staff consisted of 8 BSc graduates (from the national and international universities), 11 technical assistants (primary school, sometimes with additional vocational training) and 3 supporting staff (chiefly primary education)(Jeurissen, 1981).

The GDH had no identity as organization and no formal organizational structure when the WRAY project started. Its identity and structure became identical to the WRAY project structure (Figure 1). The project actively promoted staff training. The first opportunity for on-the-job training was in the water resources assessment study in the Sadah area in the northern mountains of Yemen. Staff were trained in the field and in the office. No clear lines of responsibility existed at the beginning of WRAY-1, but they were gradually developed during its lifetime, by assigning "section heads".

Table 1 Trends in number of staff at the General Department of Hydrogeology during the sequel WRAY phases (numbers present at the start of the project phase)

Phase	Period	PhD/MSc/ BSc	Technicians	Support	Total
WRAY-1	07/82-07/85	8	11	3	22
WRAY-2	08/85-08/86	8	11	3	22
WRAY-3	09/86-12/89	12	12	11	35
WRAY-4	01/90-04/93	23	12	13	49
WRAY-4plus	05/93-03/95	30	14	11	55
Final situation	03/95	29	16	9	54

During WRAY phases 2 and 3, when the GDH was renamed General Department of Water Resources Studies (GDWRS) the number of staff grew to 23 professionals, 13 technical assistants and 13 supporting staff (Table 1). The increase in staff during phase 3 was remarkable: from 12 to 23 university graduates. It confirmed MEB's priority to develop the water resources assessment and management capabilities (WRAY, 1986 and WRAY, 1989).

The organization of the GDH was made more formal during WRAY phases 2 and 3. A departmental structure was designed and lines of accountability were drawn. Former section heads became department directors.

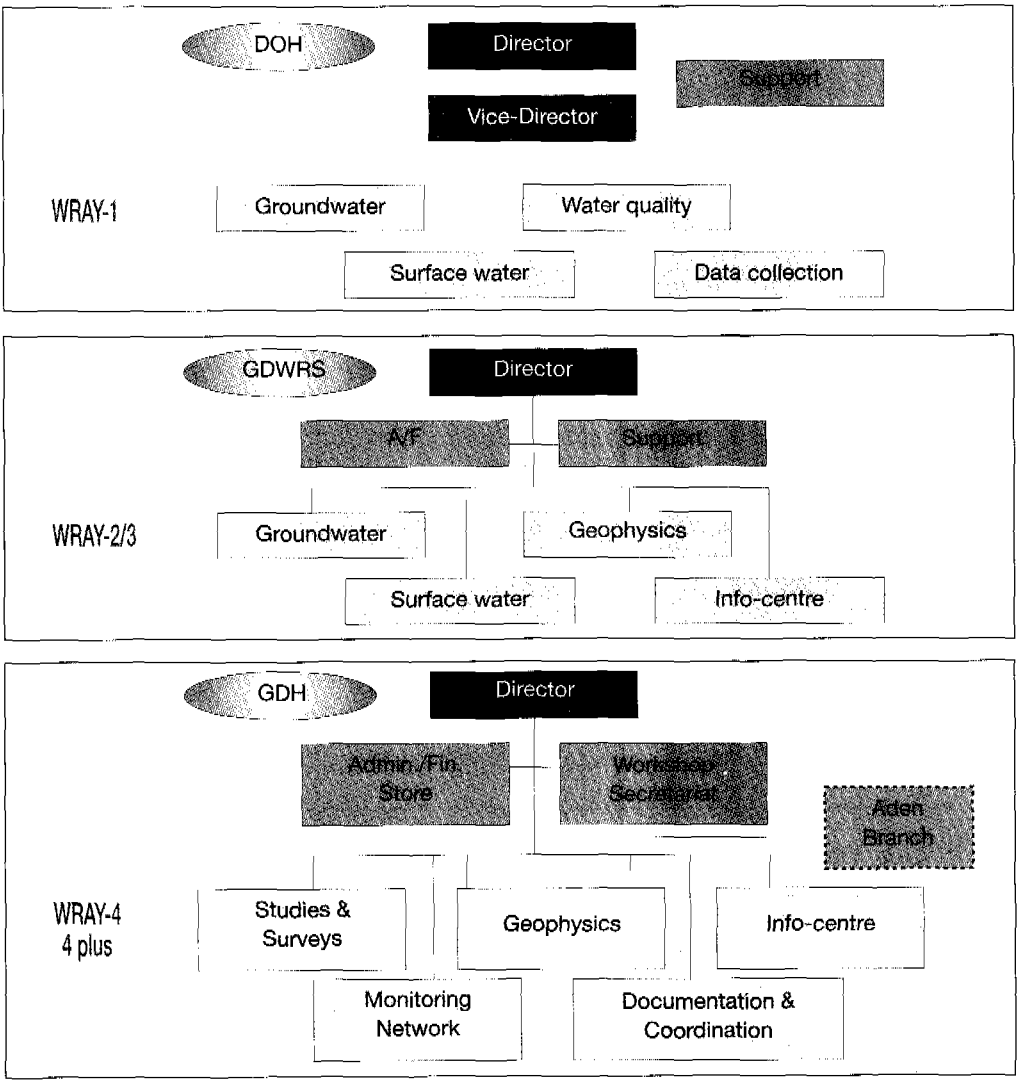

Figure 1 Organizational development of the General Department of Hydrogeology

The GDH organization was shaped into a functional organization; this entailed introducing specialist units, such as a Groundwater Department and a Surface Water Department (Figure 1).

During the WRAY-4 and WRAY-4plus phases staff increased from 23 to 30 professionals, mainly thanks to the inclusion of 6 professionals from the Aden branch.

The WRAY-4 phase started with a screening of the existing organizational structure (Negenman and Aludaini, 1991). In a preliminary performance appraisal, GDH staff reported that job responsibilities were not clear and that sometimes there was overlap between different departments (Gieske, 1991). The project advised re-organizing the GDH and establishing a 5-department product-market structure, with the aim of making each department responsible for delivering a complete product.

The departmental remits and personal job descriptions developed fell into place. Most of the staff acknowledged the responsibility given to them by demonstrating a sense of purpose. At a certain moment the various departments were working so much as separate "business units" that coordination between them became a problem. This was resolved by introducing regular staff meetings.

During the sequel WRAY phases the GDH lost a total of about 5 professionals and technicians to the MEB, but not to external parties. The assignment of experienced GDH professionals and technicians within the MEB created a more favourable environment for the GDH as this ensured that the problems of the GDH were well understood within the ministry. During the WRAY-4 and WRAY-4plus phases the GDH operated within the new organizational structure. Each department learned to initiate and finalize its own activities: to plan the work for field and office, arrange logistic and financial support, do the field and office work, analyze the data and write technical reports. At the end of the WRAY project the GDH as a whole was considered to be technically and managerially self-reliant (Schuchmann and Mohsin, 1994).

The operation of the different departments of the GDH is described in the sections below.

The Studies & Survey department is responsible for initiating and executing water resources investigations in Yemen. The department was earmarked to evolve into the "think tank" of the GDH. Therefore the most promising and ambitious hydrogeologists were assigned to it.

The Geophysics Department was the first department to become technically and managerially self-reliant. It had the longest working experience as a unit, and from the start of the project obtained contract studies from outside the MOMR and offered the department staff the best incentives because of the many days of fieldwork paid per diems.

For the past ten years, the GDH and the WRAY have sponsored the development of a National Water Resources Information Centre (NWRIC), which is in one of the departments of the GDH.

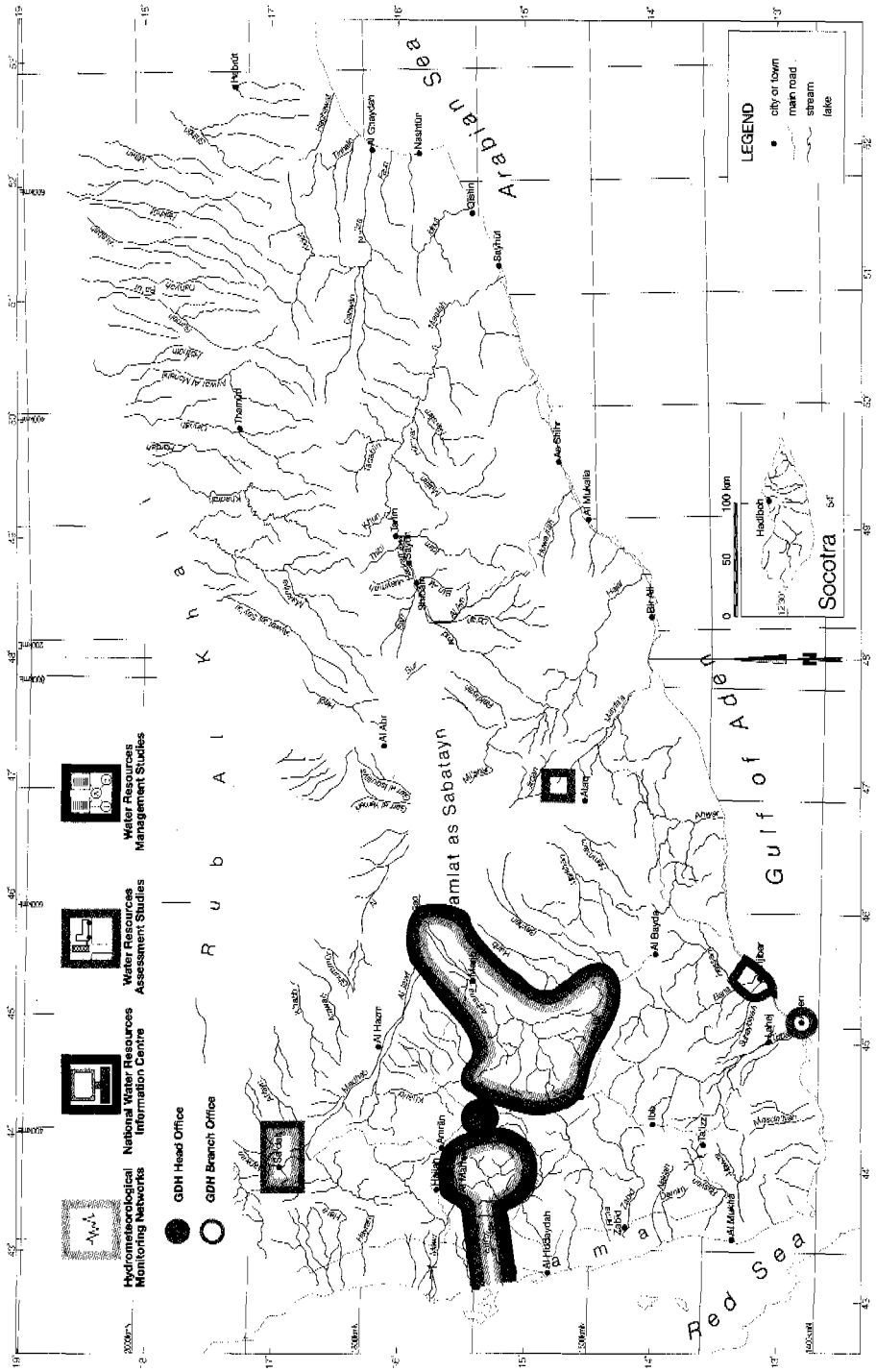

Figure 2 Technical activities of the WRAY project

This Information Centre has now achieved a high degree of operational performance and efficiency. The GDH aims at maintaining a high level of data and information exchange with all other relevant organizations. Data are exchanged with more than 20 water-related organizations in Yemen. Basic data on meteorology, rainfall, wadi discharges, surface water and groundwater levels and well inventories are collected nationwide and form the basis of a growing pool of information. For many years, data from some 300 observation stations throughout the country have been arriving at the information centre for collation and evaluation.

The Hydrometeorological Monitoring Department is the responsible for operating three monitoring networks in the Sadah, Wadi Surdud and the Wadi Adhanah/Marib areas. The networks are operated for the acquisition of meteorological, hydrological and hydrogeological data. In recent years, particulary in 1993 and 1994, the monitoring visits to the areas of Sadah and Marib have been interrupted because of the increasingly unsafe situation.

The Documentation and Coordination Department always managed to maintain a high profile in the news media in Yemen when workshops or seminars were organized by the WRAY project. Panel discussions on the TV about water resources management issues involving the Deputy Minister, TV interviews with GDH staff members and newspaper background articles formed part of the media coverage.

3 WRAY's CONTRIBUTION TO THE KNOWLEDGE ON WATER RESOURCES SYSTEMS IN YEMEN

The execution of water resources assessment and management studies was one of the main technical activities during the WRAY projects. Table 2 gives an overview of the executed studies. Figure 2 shows the areas where the studies were performed.

The water resources assessment studies were generally aimed at mapping the water resources and discovering trends in the water systems. A thorough national assessment was not feasible because of the limited resources available. Therefore the studies were performed in geographically diverse areas, to obtain representative experience and knowledge.

The study in Shabwah had the particular straightforward aim identifying a potable and sustainable water resource for the water supply of Ataq and the Wadi Jirdan in the Shabwah province. In two areas (the Wadi Surdud and the Marib Plain) water resources management studies were executed as a follow-up to the assessment studies, to develop a methodology for regional water resources planning and management. The studies provided the Yemeni decision makers with alternatives for sustainable water resources management in the areas concerned.

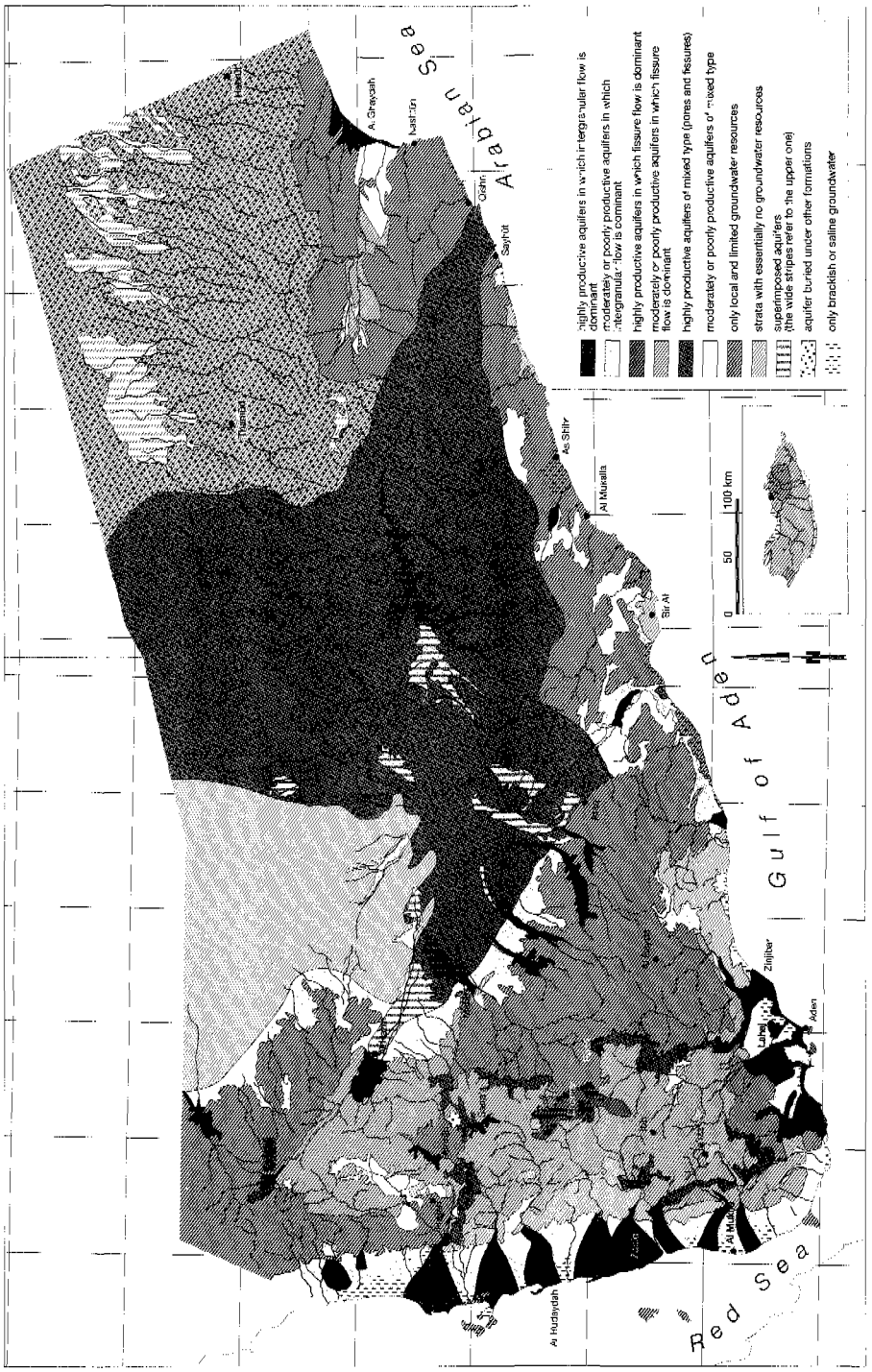

Figure 3 Schematic hydrogeological map of Yemen

Table 2 Studies executed by the WRAY project

WRAY phase	WR Assessment study	WR Management study	Geographic feature
WRAY-1	Sadah National overview		Intermontane plain Area former YAR
WRAY-2	Wadi Surdud		Western escarpment and coastal delta
WRAY-3	Wadi Adhanah and Marib plain	 pilot study Wadi Surdud	Eastern escarpment and inland delta Western escarpment and coastal delta
WRAY-4		Marib plain	Eastern escarpment and inland delta
WRAY-4plus	Abyan Delta Shabwah National overview		Southern escarpment and coastal delta Inland desert Area present ROY

One of the technical activities during the last phase of the project, WRAY-4plus, was the compilation of a summary report of the present-day status of the water resources of Yemen. The report is the result of two years of the collection and processing of information from more then 400 strategic references, data records from monitoring stations and geological and hydrogeological maps of Yemen (Gun et al, 1995). The report includes a synthesis of the existing hydrogeological maps, with some corrections and adjustments. A black and white representation is given in Figure 3.

The water resources systems in Yemen consist of surface water runoff zones which intermittently provide recharge opportunities resulting in active groundwater areas. These areas in turn are superimposed on long-established paleogroundwater systems, in which abstractions trigger dynamic conditions.

The surface water runoff zones are created by the steep mountain slopes of the Yemen mountains intersected with wadis, which under the influence of monsoonal and mediterranean climate experience two distinct rainy seasons. Orography and aspect strongly influence the weather and rainfall. The wadis convey the surface water towards coastal or inland desert deltas, but loose their water en route through infiltration. During exceptionally high floods minor amounts of surface water are discharged into the sea.

Direct recharge of the groundwater reservoirs through rainfall is generally minor in Yemen because of the high evaporation and evapotranspiration rates.

The main form of natural recharge is by infiltration of surface water from wadis. This is called indirect recharge. The infiltration losses produced in irrigated zones are quantitatively the most important form of induced groundwater recharge in Yemen.

The main groundwater reservoirs that can be distinguished in Yemen are:

- alluvial wadi fills
- Quaternary aquifers of plains, alluvial fans and deltas
- groundwater basins of the Highland Plains
- Mukalla Sandstone Aquifer.

The alluvial wadi fills and Quaternary aquifers in contact with wadis which have regular runoff receive indirect recharge. These are chiefly in the coastal zone to the west of the Yemen mountains (the Tihama), the southern coastal zone and the inland deltas oriented to the north-east and the edges of some Highland plains. They constitute the zones with active groundwater movement and have highly productive aquifers in which intergranular flow is dominant. The amount of indirect recharge in the Quaternary aquifers of the Highland plains is less than the indirect recharge in the deltas, because of the limited catchment areas and amount of rainfall.

The general features of the groundwater basins of the Highland Plains consist of sedimentary basins overlain by alluvial deposits of varying thickness with water levels about 40 metres of the ground surface. The important aquifers are chiefly formed by alluvial and sandstone aquifers with intercalations of basalts. The most important highland groundwater basins are - from north to south- the Sadah Basin, the Amran Basin, the Sana'a Basin, the Ma'bar-Dhamar Plains and Rada Basin.

The Mukalla Sandstone aquifer in the centre of Yemen constitutes the largest groundwater system of Yemen, storing huge quantities of groundwater. The aquifer was first reported by Zarubezhgeologia in 1992 in their hydrogeological map of the southern part of Yemen. Additional information collected from the oil companies about recently drilled water wells in their concession areas enabled the supra-regional aquifer to be delineated. The aquifer is highly productive. Flow through pores and fissures occurs. In Shabwah the high productivity of the aquifer has been confirmed by investigations carried out by the GDH and TNO Institute of Applied Geoscience (Negenman, 1994a).

In some zones the sandstone unit is in direct hydraulic contact with overlying Quaternary deposits. This occurs in the inland wadi deltas and in the deeply eroded valleys of the Wadi Hadramawt.

The strongly increased groundwater abstractions in Yemen, mainly for irrigation, have drastically changed the regimes and conditions of the main groundwater systems. The most easily observable effect is that groundwater levels have declined and are likely to continue declining in the future. The rates of decline are alarmingly high in many zones, especially in the Yemen Highlands, where falls between 2 and 6 m/year are common.

The water resources assessment and management studies were used as important on-the-job training opportunities for the Yemeni counterparts. In the first study the investigation techniques used still had to be explained and to be shown to them in practice. During subsequent phases the counterparts were able to be more independent. In the WRAY-4plus phase they executed the water resources assessment study in the Abyan Delta with minimum supervision.

4 THE WATER POLICY LIFE CYCLE IN YEMEN

4.1 The water sector during the last three decades

After the proclamation of the Yemen Arab Republic (YAR) in 1962, modern government was established and the country relinquished isolationism. In 1967, the People's Democratic Republic of Yemen (PDRY) was proclaimed, after it withdrew from the British Commonwealth.

The two young republics had diverging philosophies on their own social and economic systems. In the Yemen Arab Republic a rather open and market-oriented system was followed, while in the People's Democratic Republic of Yemen a Marxist central planning system was adopted. The two countries merged in 1990. In May 1991 a new constitution was approved in a referendum.

The events in water resources management and development in Yemen during the last three decades, during which groundwater levels in the Highland Plains have fallen by 40-100 m, can be characterized chronologically as follows:

* establishment of new governments in the separate Republics and re-orientation and re-direction of the national economies
* unprecedented and uncontrolled increase of groundwater development in private and government sectors, as a result of the introduction of modern technology and increasing water demand
* water resources development studies
* lack of coordination between the different water-related agencies and authorities
* water resources assessment studies confirm rapid depletion of the groundwater resources
* first attempts to introduce water resource management and control (establishment of High Water Council in 1981)
* first signs of adverse effects of large-scale groundwater abstractions in the highlands become apparent (drying-up of springs and shallow wells, deepening of boreholes)
* continued uncontrolled increase in groundwater abstractions (Sadah, Sana'a, Rada, Tihama)
* water resources assessment and management studies prove that groundwater abstractions exceed groundwater recharge in most areas; simulations predict critical depletion within 10-15 years

* donor coordination attempts to coordinate actions, plans and projects in the water sector.

The present decade (the nineties), until the beginning of 1995, may be characterized as follows:

* continued uncontrolled groundwater abstractions and drilling
* deepened and dry wells in highland plains
* several new attempts to introduce water resource management and control (draft legislation submitted to parliament)
* growing awareness of the population and of water resources professionals about the gravity of the water resources management issues in Yemen
* identification of a large supra-regional groundwater resource in the eastern part of the country
* donor coordination
* start of the formulation of a National Water Policy
* increased coordination between water-related agencies and authorities.

After unification in May 1990 three attempts were made to introduce water resources management:

* The newly formed Ministry of Agriculture and Water Resources (MAWR) was made the responsible for the planning, development, management and control of the water resources. The assignment of all these responsibilities to one ministry met strong opposition, including the GDH, and split the water sector into two camps. Because the MAWR represents and serves the irrigated agriculture sector, which is the largest water user in the country, some were unhappy about making it responsible for the management of the water resources. However, MAWR was supported by the World Bank (Land and Water Conservation Project). In April 1991 a draft Water and Irrigation Law proposed by the MAWR was submitted. In December 1991, a decree was issued giving the MAWR the responsibility to regulate the drilling of wells until the enactment of that law. The law was never enacted and it is unclear how the decree is being observed. In the Amran area, where it should have been introduced first, no control is taking place.
* In 1990 the Technical Secretariat (TS) of the High Water Council (HWC), which since 1986 has been supported by a Technical Assistance project financed by UNDP, submitted draft National Water Legislation which included a proposal to reorganize the HWC and re-establish the Technical Secretariat. No action was taken. The effort of the TS was reinforced by a Rapid Water Sector Overview conducted in 1991 which set a timetable for moving ahead. Again, no action was taken by the government.
* In 1992 the MAWR, with support of the FAO, initiated the development of an appropriate institutional and policy framework to enable the government to undertake an integrated, comprehensive and sustainable approach to water resource management. An interdisciplinary team of Yemeni specialists, including various GDH staff, was assigned to participate in the process. The exercise resulted in the presentation of a National Water Policy Document in December 1993.

The National Water Policy Group advised that the planning and regulatory functions be organized separately from the water users. The MAWR openly discussed various options and acknowledged that it should not necessarily be vested with the planning and regulatory functions.

The momentum created by the National Water Policy workshop proved to be important. The project "National Water Resources Authority" started in March 1995.

4.2 Policy life cycle

To put the process of the national water policy and strategy formulation in Yemen and the role of the WRAY project in a historic perspective it is helpful to use the concept of the policy life cycle (Winsemius, 1986). Water policy and strategy go through a life cycle in which four stages can be distinguished (Figure 4):

1 problem recognition
2 policy formulation
3 problem solution
4 management.

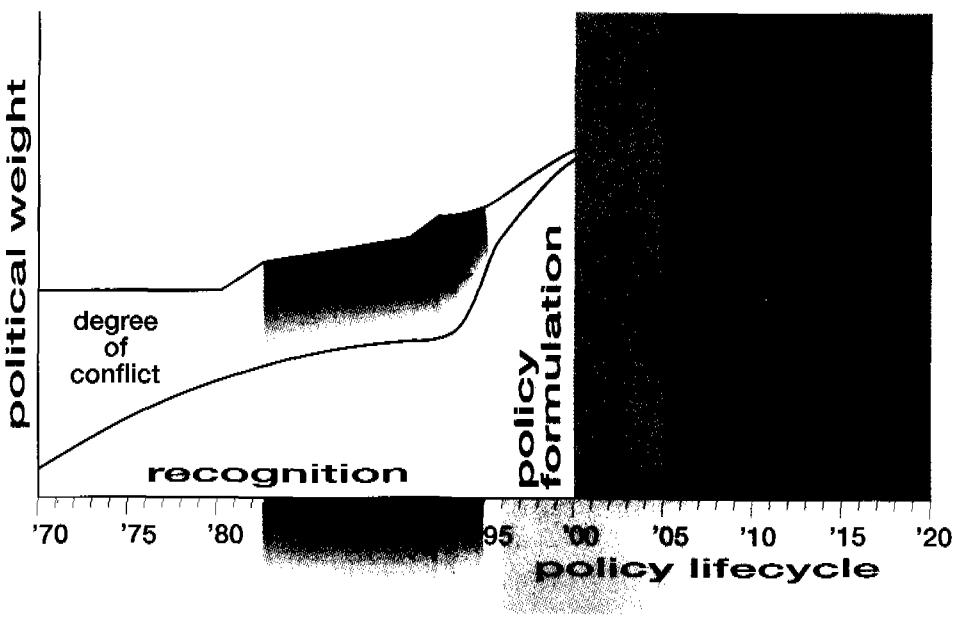

Figure 4 Development of the water policy in Yemen

Problem recognition

During the phase of the problem recognition the first signals are received that there might be a problem. The signal that the groundwater resources in Yemen were being depleted at an alarming rate came from the researchers. In Yemen the phase of problem recognition extends from the beginning of the seventies to the present day, although efforts have been made to start the policy formulation. The entire WRAY cycle therefore also falls in this problem recognition phase.

After the unification of Yemen in 1990 the MAWR was assigned the responsibility for the water resources, resulting in more conflict in the water sector, but also resulting in more weight for the water issue on the political agenda.

The tide changed after the Yemeni Task Force's formulation of a draft National Water Policy, in which consensus was reached on certain principles in 1993: the conflict de-escalated sharply. An opening was created to form an independent "National Water Resources Authority" to be created by merging the GDH and the TS. This opened the way to the next phase of the water policy life cycle: policy formulation.

Policy formulation

The exact boundary between the subsequent phases of the policy life cycle is arbitrary. In the case of the policy life cycle in Yemen it is considered that the formulation of water policy and strategy will take place in 1995, after the National Water Resources Authority has been established. During this phase the emphasis will be on regional water resources management strategies, testing and evaluating effective measures for the water resources management problem and possibly the introduction of preliminary measures for control (such as control of drilling based on interim laws). It is anticipated that this phase will last 4-5 years.

Problem solution

During the third phase, the problem solution phase, the water resources strategy designed must be implemented by introducing the proposed measures. This will require creative interventions to re-structure water demand, especially in the highlands. Elements of decentralization of authority and the preparation of regional and local organizations are important during this phase.

After the implemented measures have given rise to the envisaged effects and the problems have been reduced to politically, socio-economically and environmentally acceptable proportions, the fourth phase starts. The duration of the third phase will vary for the different regions in Yemen from 5-10 years.

Management

The fourth phase, which might start after 2005, is the actual management phase during which the operation of the water resources system needs to be optimized within the constraint of sustainability. Actual management can only take place when the policy has been defined, the problems tackled and the water managers assigned.

During the process of the policy life cycle different parts of the water resources "institution" will be charged with different aspects of the policy life cycle. For Yemen this means that the present emphasis needs to be shifted in the near future from Capacity Building in water resources planning towards water resources management implementation and later to water resources management monitoring and control.

5 THE WRAY PROJECT APPROACH

The approach used by the WRAY project to achieve its objectives in Capacity Building for water resources management evolved gradually over the consecutive WRAY phases. From the onset, before the term Capacity Building had been introduced, the WRAY project started building up the counterpart organization by according the same importance to the process of fully involving the Yemeni counterparts in the technical activities as was accorded to the actual technical deliverables. The emphasis was put on investing in the people and their organization. Human Resources Development was a strong point in the WRAY project from the onset.

This approach is different to that found in many other technical assistance projects, in which counterparts are rarely accepted as full participants in the project and are merely used to facilitate the work. As deadlines approach, these projects tend to drop counterparts and to release them from any responsibilities as there is no time and no patience to continue supervising them.

The WRAY project's approach consisted of interventions at four levels: the individual, the organization, the sector and the nation, contributing to fulfilling the commitments relating to training, management, mandate and integrated water resources management at these levels (Figure 5).

At the individual level the emphasis was on technical and managerial training, at the organizational level on modern management, at the level of the sector on the fulfilment of the mandate for national water resources assessment and information management, and at the national level on the participation in the national water policy formulation, supporting the concept of integrated water resources management. The activities executed at each level are indicated in the charts in Figure 5.

The introduction of modern management techniques for the GDH directors was a new element within the training during the 4th phase.

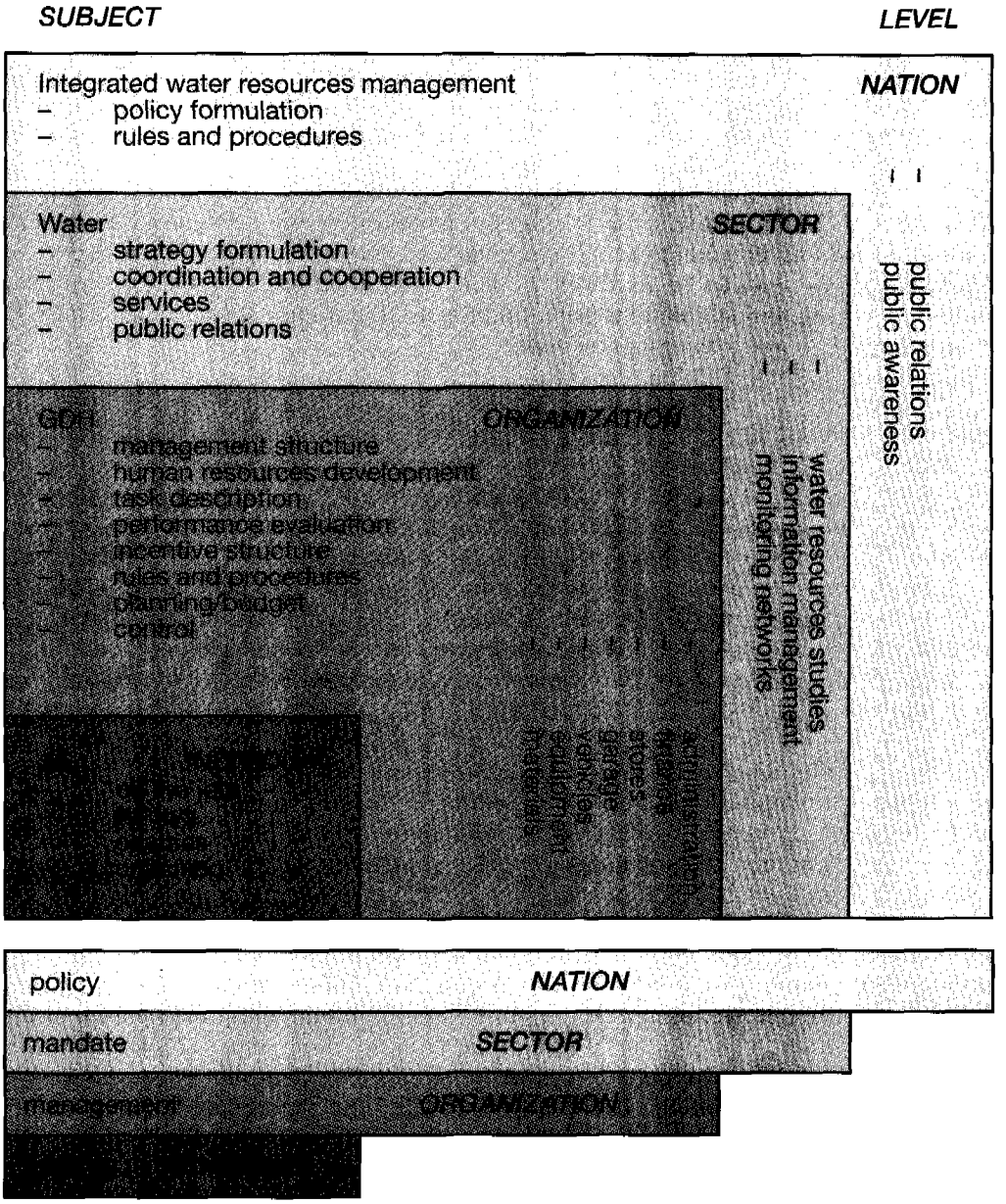

Figure 5 Capacity-building strategy of the WRAY project

All the managers were astonished to find that besides being hydrogeologists or geophysicists they were also considered to have management knowledge and skills. Management in the GDH is chiefly established by authority and not by merit. The authority gives the manager the feeling that the staff under him need him, e.g. to approve requests for a day-off to participate in a wedding, or to organize transport. It was difficult for some department directors to grasp that being a manager meant "the virtue of getting things done through people", that the manager needs people in order to achieve the department's aims realized (Stoner and Freeman, 1989).

The experience of the WRAY project Capacity Building is one of a vertical and horizontal intermeshing of the water resources management "institution"[1].
At the subsequent levels of the organization, the sector and the nation, well-trained professionals are actively and effectively involved. This has been achieved by a coming together of the following critical management interventions:

1 the consistent strategic aim of the GDH within the Yemeni water sector to become a leading institute in the fields of water resources assessment and information management
2 the creation of an organizational structure within the GDH that matches the strategic aim and facilitates the implementation of that aim
3 the management of functions such as developing human resources, planning and organizing the work, monitoring of performance, and motivating staff in such a way that these functions are consistent with the strategy and the organizational structure
4 the exercising of diplomacy at the level of water policy formulation that pursues the enhancement of GDH's role in future water resources management in Yemen
5 the continuous orchestration of the interventions mentioned so that they reinforce each other even though environmental conditions change.

The satisfactory results in training individuals, the good management of the GDH organization and the building up of the reputation of the GDH in the water sector proved to be very important. They made it possible for GDH to contribute effectively in the process of water policy formulation in Yemen. If one of the levels had been built up to a lesser extend the GDH would have had less impact and would not have been able to achieve the place and role in the water sector in Yemen it occupies today.

[1] Here "institution" is broadly defined, to include both the set of basic rules (laws, regulations, customs) as well as the organizational arrangements that govern water resources management (After Israel, 1987)

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- The WRAY project considered the process of fully involving the Yemeni professionals in all aspects of the technical activities to be of equal importance to the technical deliverables. This process-oriented approach resulted in building a technically and managerially self-reliant organization, capable of fulfilling its mandate, within a period of 15 years.

- On-the-job training has been one of the most important training tools for the WRAY project and was considered an essential element in the process of education which began during the formal teaching at university and which continued during formal courses and fellowships during the project.

- The introduction of modern management techniques within the GDH organization resulted in activating the department directors and the group of professionals. This substantially increased the efficiency and the effectivity of the GDH.

- The reputation of the GDH in the Yemeni water sector rests upon the mobilization of the collective skills of the directors and professionals and the quality of the technical output and services provided.

- The water policy life cycle in Yemen is still in the phase of problem recognition in spite of several attempts since the eighties to introduce management and control. The WRAY project contributed significantly to putting water resources management on the political agenda, by increasing knowledge about the water resources systems and raising public awareness of the water resources management issues in Yemen. Once the proposed National Water Resources Authority has been established, actual policy formulation in Yemen will start. This is foreseen during 1995.

- The emphasis on the strengthening of the local capabilities in the WRAY project lay in the domain of the execution of water resources assessment studies and information management. This fitted in well within the problem recognition phase of the water policy life cycle.

- The problem recognition phase in the water policy life cycle in Yemen is long; this is because of the absence of critical situations or socio-economic shocks due to actual water shortage that might have increased the political weight and challenged the decision makers to opt for water resources management and control. Development of the water resources institution was also hampered because of a lack of overview and insight into how implementation of water resources management would affect the different sub-sector organizations.

- The Capacity Building strategy which the WRAY project followed was a process of vertical and horizontal intermeshing of the GDH in the water "institution". Vertically,

attention was paid to the levels of the individual, the organization, the sector and the nation. Horizontally the GDH promoted coordination and cooperation.

- Effective participation of the GDH in the national water policy formulation of Yemen evolved from the individual GDH staff member, through the strength of the GDH organization and its reputation in the water sector, to the national level.

6.2 Recommendations

- In addition to the technical objective Technical Assistance projects should have an institutional objective. For instance, a project for the formulation of a national water strategy should have the objective of a self-reliant local water planning and management organization, in addition to the objective of the national water strategy.

- Capacity Building for the water sector in Yemen should continue to support the establishment of the National Water Resources Authority. The emphasis of Capacity Building in the coming 5 years will have to be on developing the water resources planning and management functions of the water institution. This is related to the fact that the stage of the water policy life cycle in Yemen is presently shifting from problem recognition to policy formulation.

- On-the-job training should be formally introduced within Capacity Building projects by assigning counterparts to a task and regularly having the local manager or resident project expert monitor their performance.

- Training in management science should be compulsory for local managers in water sector organizations.

- To build strong local capacity, the organization in question needs to have a consistent strategic aim, an organizational structure that matches the strategic aim, a dedicated human resources development plan, diplomacy at the policy formulation level and a local leader who orchestrates these interventions continuously.

- Capacity Building for water resources management is a long-term process which requires long-term commitment from the ESA's. It must be co-terminous with the water policy life cycle.

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Netherlands Experiences with Integrated Water Management (Proceedings of the meeting in Delft, The Netherlands, 5 October 1995)

INTEGRATED WATER RESOURCES MANAGEMENT IN BANGLADESH: THE COMPARTMENTALIZATION PILOT PROJECT, TANGAIL - A PROJECT SUPPORTED BY EUROCONSULT/LAHMEIJER/BETS IN ASSOCIATION WITH DELFT HYDRAULICS

J.I. Crebas

ABSTRACT

In Bangladesh, floods and flood management are a part of life. Minor floods are in fact beneficial, but major floods can be devastating to society, industry and the country's economy. The Compartmentalization Pilot Project (CPP) is one of the Flood Action Plan projects the World Bank agreed upon with the Government of Bangladesh in 1989.
A Compartment is a (semi) protected area or part thereof in which effective water management particularly through controlled flooding and controlled drainage, is made possible through structural and institutional arrangements.
The aim of the project is to develop, in consultation with the local population and institutions, an integrated water management system accommodating the water requirements of various sectors such as agriculture, fisheries and human habitation. Improved drainage and reduction of flood levels will result in increased rice production and the possible adverse effects on fisheries will be minimized by mitigating measures.
In this paper emphasis is put on Water Management Planning for Agriculture and Fisheries in the Compartment.

1 INTRODUCTION

Following the severe flooding of 1987 and 1988, the Government of Bangladesh completed the National Flood Protection Program, the Flood Policy Study and the Flood Control Prefeasibility Study (both with UNDP assistance).
Also other organizations produced their plans in that respect. In June 1989, the World Bank agreed to coordinate the various flood control initiatives and in November 1989 produced a Action Plan covering period 1991 - 1995.

The main core of the Flood Action Plan (FAP) consists of a phased programme of flood control activities supported by special studies, surveys and pilot projects. A new approach of water management emerged from the particular setting in which Bangladesh finds itself. The ideas of controlled flooding and controlled drainage were introduced. The compartmentalization concept was at that time very much an idea that needed extensive field testing under practical operating conditions.

Thus the Compartmentalization Pilot Project (CPP - FAP 20) comprising pilot areas on each side of the Brahmaputra river was proposed. The two pilot areas would be reasonably representative of the protected areas.

Compartmentalization should lead to a sustainable development which would imply:
- proper resource development
- people's participation
- focus on the disadvantaged groups of the population
- proper institutional setting of the water management system
- feasibility and flexibility.

2 BACKGROUND

Bangladesh through its complex network of rivers drains an area of about 2 million square kilometres of which only 8% lies within its territorial boundaries. This physical setting severely limits the degree of control and management that can be applied to the inflow of water both in the monsoon season and during the dry period.

Owing to its geographical location, Bangladesh is exposed to a wide range of extreme natural phenomena; it is located on a fragile portion of land in the world's largest delta which comprises three of the world's most unstable rivers. The rivers flowing into Bangladesh drain some of the wettest catchment areas on earth with average yearly rainfalls as high as 11 m. In addition, Bangladesh is one of the most densely populated regions in the world. Life in Bangladesh is pervasively influenced by the rivers.

The rivers also cause vast damage when they sweep over the country during massive floods. Approximately 40 per cent of the country is subject to regular flooding often causing death and diseases as well as extensive damage. Apart from river floods, Bangladesh suffers severely from storm surges generated in the Bay of Bengal. The surge waves are induced by

tropical cyclones and can reach heights of 7 m as they approach the coast. The consequences are often disastrous and have cost hundreds of thousands of lives in the coastal regions.

The need for integrated water management systems varies within the country. In rural areas, floods provide a livelihood when not too extreme and the rural population has, over the centuries, perfected its ability to cope with the water. In many such regions it is desirable to maintain the beneficial aspects of floods, e.g. for the water demanding rice and jute crops and for inland fisheries. Under these circumstances, control - rather than elimination - of floods is required.

3 THE PROJECT

The Compartmentalization Pilot Project is a joint programme of the Government of the People's Republic of Bangladesh, the Netherlands and the Federal Republic of Germany. Besides the Bangladesh Water Development Board as the Executing agency, other agencies participate in this multi-disciplinary project. The project started in July 1991.

The CPP has to establish and to test the concept of compartmentalization by establishing compartments in protected areas.

Besides the technical measures to be taken, the socio-economic and institutional aspects are an important part of the project. In the future the institutions concerned should support that the people who get the benefits or those who may be disadvantaged will have a say in the water management in their area. Therefore the inhabitants of the compartment as well as in the adjacent areas are involved from the very beginning, before any technical or institutional measure is realized. People's participation is considered as a key component for successful implementation of the project.

Water management comprises a number of activities which are related to many, often of diverse, interests (urban and rural development, agriculture, fisheries, flood protection, navigation). The beneficiaries are involved in the whole process and should in a later stage actively participate in Operation and Maintenance of the water management system. The disadvantaged will be compensated as much as possible. Special attention is given to landless and women; all these groups are represented in the proposed institutions being established.

The technical measures consist of rehabilitation and construction of embankments and flood protecting structures, re-excavation of drainage channels (fish friendly), water regulating structures, culverts, etc. In the course of the project duration, the system of water management will be tested in consultation with the representatives of beneficiaries and the disadvantaged in the (sub-)compartments.

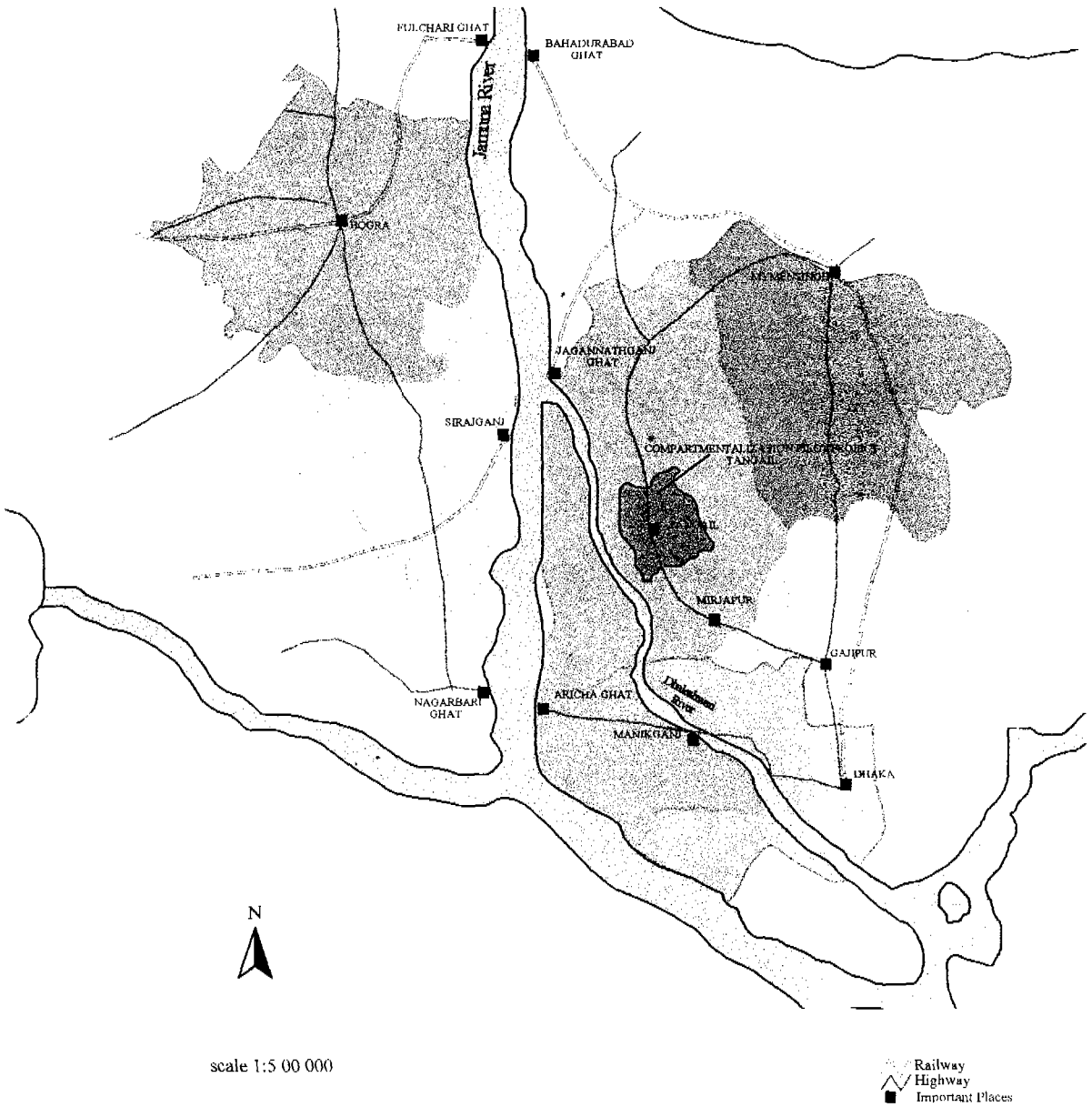


Figure 1 Compartmentalization Pilot Project Tangail, regional setting

4 THE TANGAIL COMPARTMENT

The Tangail Pilot Project is located on the left bank of the Brahmaputra, in the vicinities of Tangail Town. The area is bounded by an existing horse-shoe shaped embankment along the Dhaleswari and Elanjani rivers in the west, the Lohajang river and Gala khal in the north and the Pungli river in the east. The southern boundary is formed by an existing earth road between Silimpur and Karatia (Figure 1).

The area is comprised of 13212 hectares and occupies part of the Young Brahmaputra Floodplain. The overall drainage is away from the Dhaleswari and Pungli rivers towards low-lying land in the south-east. Overall land elevation is rather flat with contours varying between 12.5 and 7.5 m+PWD (Public Works Department datum, which is 0.46 m below GTS, Grid Triangular Survey datum, which is defined as the mean sea level at open sea). However, in detail, the relief comprises a complex network of ridges, basins (beels) and old channels (khals). Most of the land goes under water in the monsoon season. Flooding of depressions normally begins in May-June with the onset of the pre-monsoon rainfall. The flooding reaches its peak in July-August.

Agriculture in the project area is dominated by rice crops. Dry season irrigation by ground water within the area is intensive. As a result, irrigated Boro HYV (High Yielding Variety) is the main crop, at present producing 50 - 60% of the total rice yield. In years of early rainfall, Boro HYV grown on lower elevations cannot be harvested and the total rice production is hampered. In contrast, land utilization in the monsoon season is minimum, 40 % of the lower land remaining fallow. Low yielding Deep Water Aman predominates then, whereas only 2 % of the net cultivable area is covered with high yielding Aman varieties. Uncontrolled floods from river water and impeded drainage are the major limitations for further enhancement of agricultural development.

5 THE BASICS OF THE (SUB-)COMPARTMENTAL SETTING

A Sub-compartment is: a sub-unit of a compartment, in which to a certain extent, the water management can be controlled by the people living in the area. These beneficiaries are represented by a Sub-Compartmental Water Management Committee (SCWMC). A sub-compartment may consist of one or more systems.

A System is: a sub-unit of a sub-compartment (or in case of one system, this system is equivalent with a sub-compartment), which acts as a catchment area controlled in many (but not all) cases by an independent inlet and outlet. A system may consist of one or more chawks.

A Chawk is: the lowest level of hydrological uniformity. Most chawks have inlet(s) and outlet(s). The "chawks" are readily recognizable as manageable field units usually bordered by topographical features; generally located in between villages (settlements), roads, khals/rivers or embankments. These chawks are socially and agriculturally quite familiar to rural people in the project area.

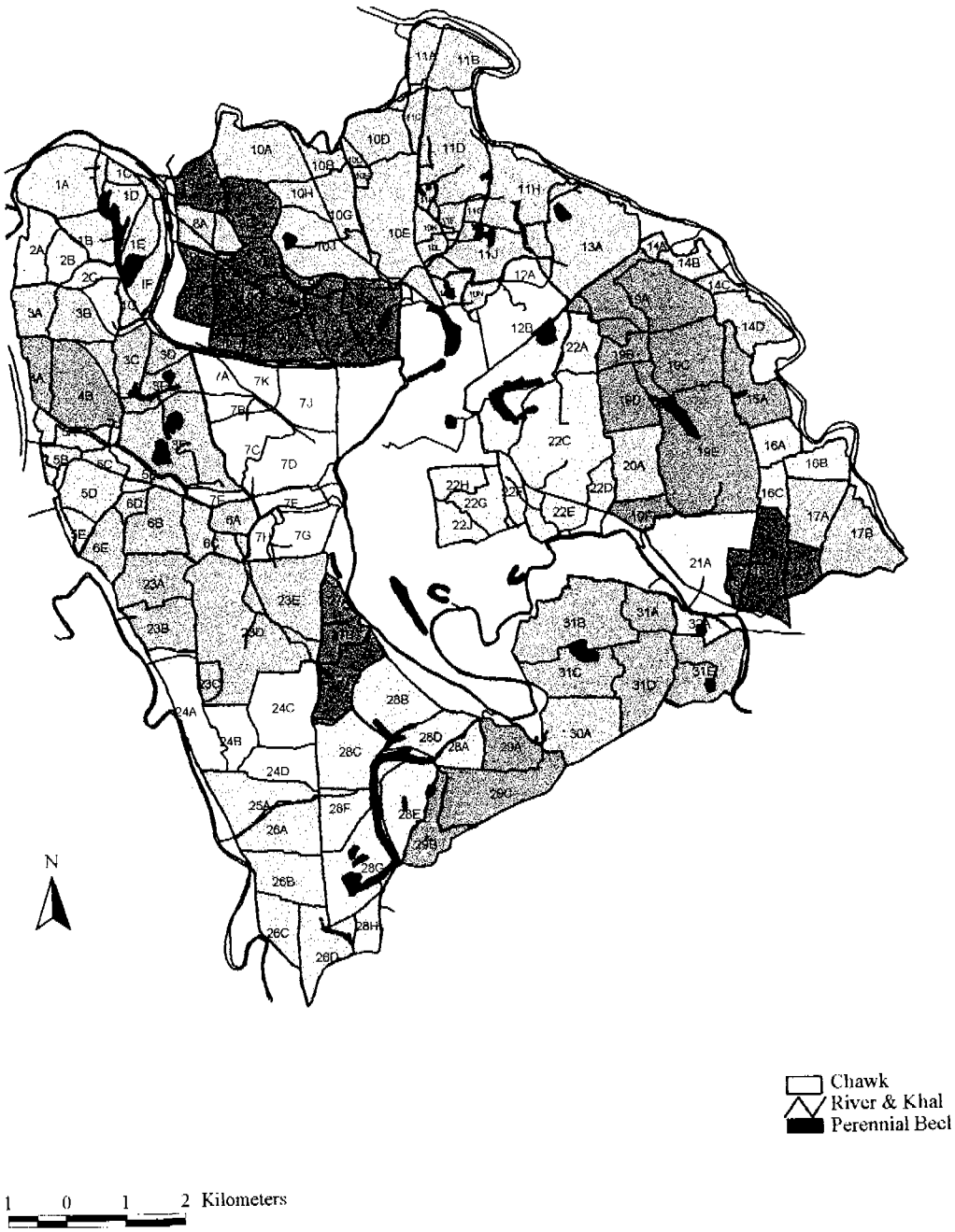


Figure 2 Tangail Compartment, systems and chawks

The chawks might have both high, medium and lowland, and may contain a beel or khal; but since their borders are formed by infrastructure (roads, villages, khals etc.), it would be possible to regulate water levels to suit certain desirable and profitable crops during the monsoon flood period and to retain or drain out water in pre and post monsoon.

In Figure 2 the (sub-)compartmental setting is shown.

6 WATER MANAGEMENT PLANNING FOR THE COMPARTMENT

6.1 General

The main objective of water management in the Tangail Compartment is to improve conditions for agriculture, while another objective is to reduce the risk of damage in general in the area during times of excessive floods. At the same time the adverse effects of water management interventions on fisheries need to be minimized.

6.2 Selected development scenario

In the Planning and Design phase of the project a one-dimensional flow model was developed for the Tangail Compartment. After calibration and verification of the model, it has been used to test various development scenarios. Based on surveys, modelling results, consultations, engineering possibilities and institutional requirements, 6 implementation alternatives were formulated. The development scenario finally selected comprises the following (Figure 3):

- an inlet structure in the Lohajang (Main Inlet) to control the water level in the Lohajang downstream of the structure during the monsoon such that it acts as a drainage channel for the sub-compartments
- peripheral inlet structures in the horse-shoe embankment to let water in from the bordering rivers, if needed
- internal outlet structures along the Lohajang to control the drainage from the sub-compartments
- water control structures (small water regulating structures) to control the water level of a chawk or a group of chawks upstream of these structures.

To improve drainage, various khals will be (re-)excavated.

6.3 Benefits of selected development scenario

The benefits of the selected development scenario with respect to agriculture and fisheries are discussed in the following.

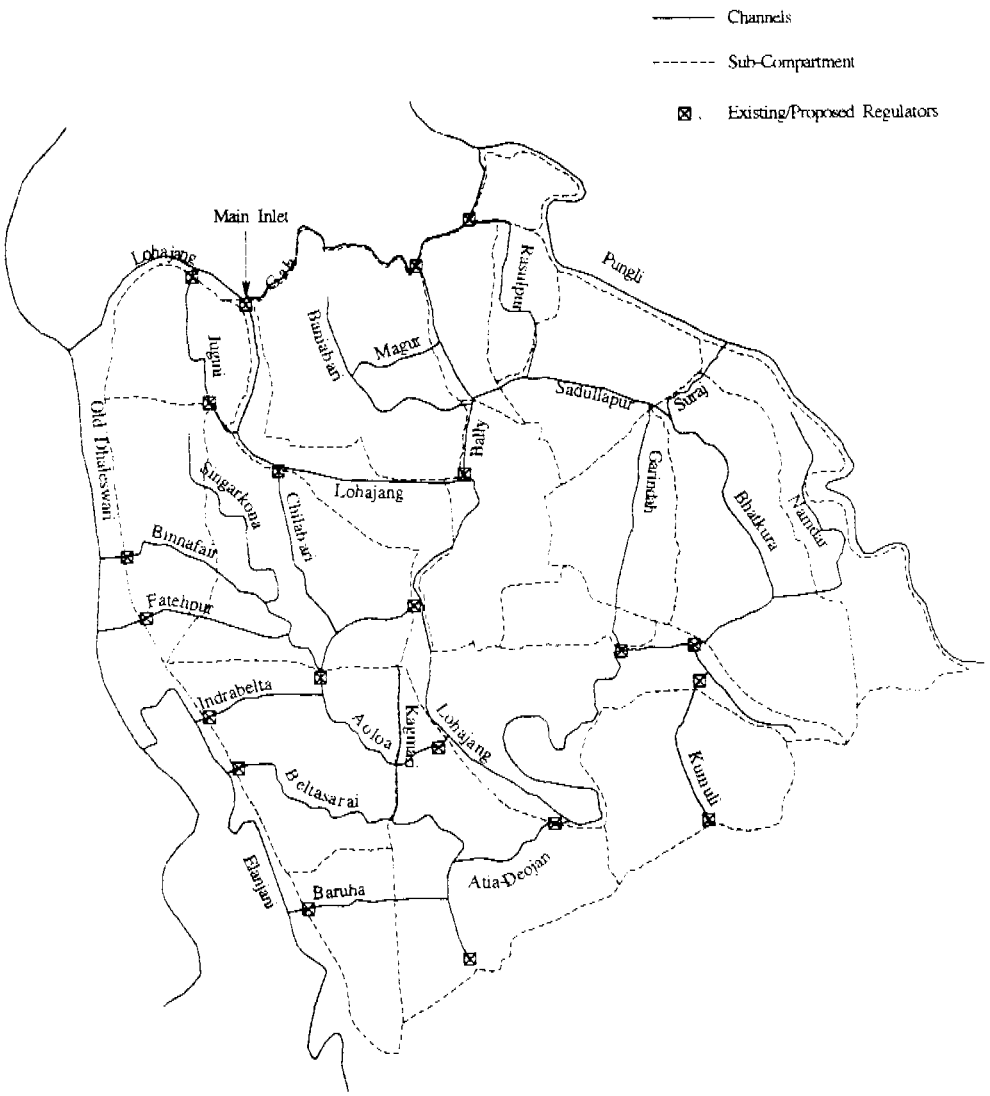


Figure 3 Tangail Compartment, peripheral and internal structures

Agriculture

There are 4 distinct agro-hydrological periods: pre-monsoon, monsoon,post-monsoon and the dry season:

- pre-monsoon (March to June)
  During this period the Boro is harvested. It is cultivated from lowland up to high land areas. This crop may be damaged by water logging caused by excessive early rainfall or an early high stage on the river.
  Damage will be reduced by providing an effective drainage system. Therefore khals will be excavated and re-excavated.
- monsoon (July to September)
  A variety of crops is grown that can resist different levels of flooding. To increase T.Aman (HYV) cultivation, the water levels within the compartment should be lowered considerably. The optimum water depth range for this crop is 0 - 30 cm. The highest water level after the end of August will determine the area potentially planted with T.Aman (HYV).
  Controlled flooding includes maintaining optimum water levels throughout the whole compartment. Detailed water management however requires a large number of control structures. Within the level of acceptability by the people of the project area, compromises have been made and second-best options were chosen.
- post-monsoon (October)
  During this period the land will be drained as early as possible in order to permit the cultivation of oil-seeds from November onwards, so to extend the potential area for oil seeds.
- dry-season (November to February)
  The dominant activity during this period is the irrigation of the Boro crop by means of shallow and deep tube wells.
  Early drainage will enable timely sowing of Boro and a slight increase of the potential area. Therefore khals will be excavated and re-excavated.

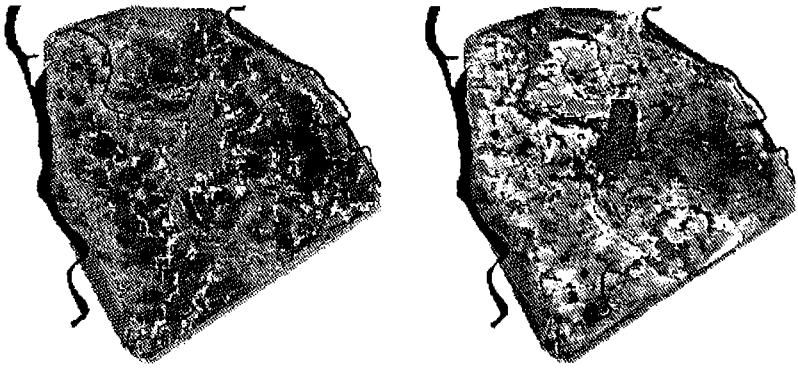
Summarising it can be stated that in the future situation during pre- and post-monsoon the drainage will be improved while during monsoon the flood levels will be reduced.

Fisheries

In the CPP Tangail area a total of about 500 tons of fish is produced annually, of which about 75 % comes from beels and floodplain. Fish is the main protein source in the area in particular for the poorer strata Culture based fisheries is not developed and this area is one of the lowest inland fish producers of Bangladesh.

The existing situation is favourable for floodplain and beel fisheries. There is free access from the major rivers into the khals, floodplain and beels for fish migration. Controlled flooding and drainage during the monsoon season will impair this situation in two manners:

- the migration of fish is hampered by (gated) structures
- the inundated area within the compartment where the fish can feed and spawn is reduced.



August 20, 1987 (Without Project) August 20, 1987 (With Project)

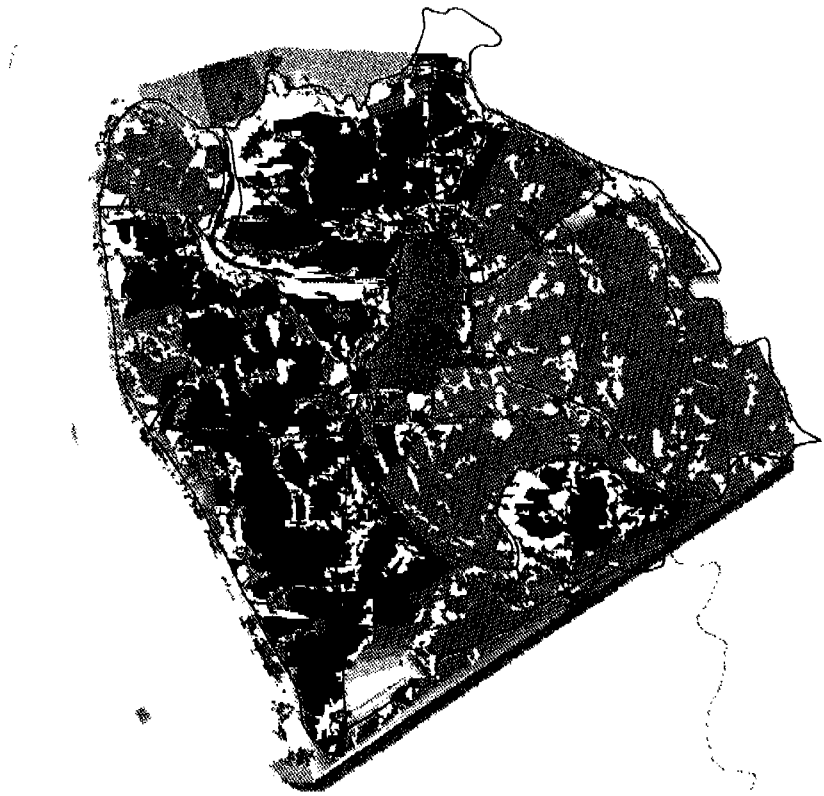


Figure 4 Simulated impact on flood levels - 1987

A slight compensation for the generally negative effect for beel fish is obtained when the highest water level after August is maintained throughout the monsoon season by controlled drainage, thus partly maintaining the feeding ground for beel fish. This is also beneficial in years with a very modest river flood.

The water management elements as required for agriculture are adjusted in order to minimize the negative impact for fish. To allow fish-hatchlings to enter the compartment, all structures will be open till July 15 or till the first wave passed through the compartment. Some of the key control structures have a fish friendly design. Sill levels of khals connected to a perennial beel will be adjusted to enhance beel fisheries. Moreover, proposals are made to develop pond culture fisheries to mitigate the production loss.

7 OPTIMIZATION OF THE STRUCTURE OPERATION

After completion of the design, a cluster-wise (a cluster comprises one or more sub-compartments) detailing of the mathematical model has taken place in order to test structure operation rules for the selected development scenario.

Proper operation of the control structures is the basis of water management in the Tangail Compartment. General operation rules were made based on a number of assumptions.

In the Flood Management Model (FMM) study the Tangail Compartment was selected to test structure operation optimization. An FMM integrates a one-dimensional numerical flood model with a Geographic Information System (GIS). It is primarily designed for generating flood inundation and flood comparison maps, but also facilitates the development of operational guidelines for flood control structures.

To be able to simulate the structure operation, a special structure operation function was developed for the one-dimensional hydrodynamic model.

General operation rules were tested with average target water levels for the sub-compartments. Figure 4 shows flood depth maps of the "Without-" and "With-Project" cases on August 20, 1987 (peak flood during the monsoon of 1987). The "With-Project" case includes the Main Inlet in the Lohajang river in the northern embankment, controlling the water level just downstream of the inlet at 11 m+PWD. All peripheral inlets are operated on the downstream target water level while the internal outlet structures along the Lohajang are operated on the upstream target water levels. In both "With-" and "Without-Project" cases Tangail Town (in the centre) is marked flood free because no elevation data is available. The "With-Project" case shows more flood free areas along the Lohajang to the north and in the south-eastern area. The comparison map shows an increase of water level of about 20-40 cm in the northern adjacent area. In the compartment the light-grey shade shows a decrease in water level of about 50 - 100 cm while the dark-grey shade shows a decrease in water level of more than 140 cm.

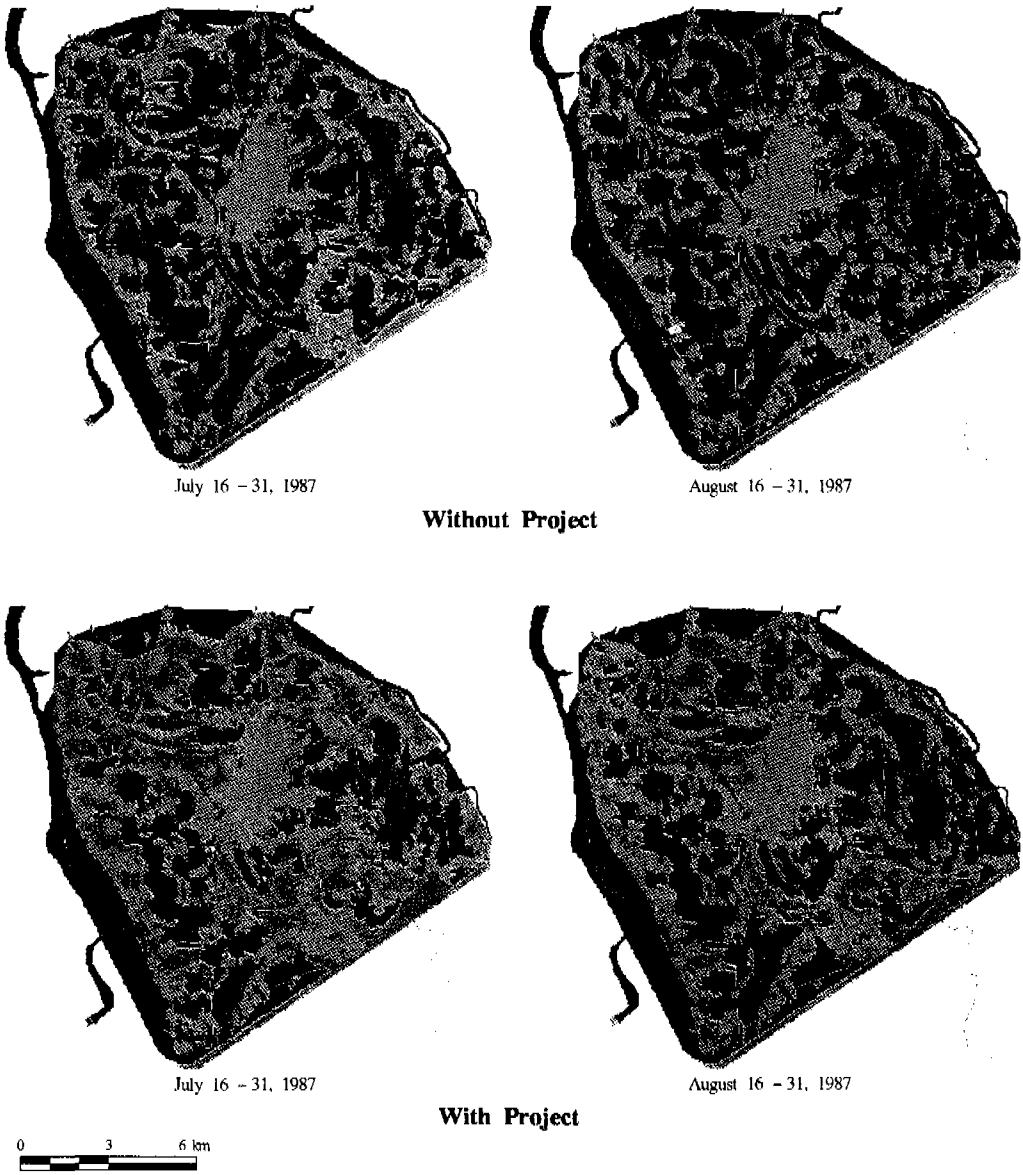


Figure 5 Simulated impact on crop damage - 1987

An example of the type of crop damage mapping that is possible under FMM is shown in Figure 5. These maps take into account the duration for which a crop can tolerate inundation and also the crops growth stage. A critical depth criterion for each period (the depth of water which will damage the crop), has been assumed for all crop types. A period of analysis of 15 days (half month) has been chosen, within which the maximum depth which is equalled or exceeded for 3 consecutive days is determined. If the critical depth is exceeded by this maximum, the crop is assumed to be damaged. The dark colour shows the areas where the crop will be damaged.

In the project office in Tangail a Flood Damage Assessment Study was started to estimate expected yearly damage to crops and fish catch due to flooding, for the "With-" and "Without-Project" cases. The expected damage will be calculated using flood and flood duration maps generated by FMM for historical years.

8 PROJECT IMPLEMENTATION

The implementation is ongoing and is slower than according to the original planning.

Canal excavation appears to be the most difficult item in the implementation, mainly because of lengthy land acquisition procedures, involving many owners, partly because the riverbeds are used as seedbeds and even more so because land owners are not willing to give up their land (attitude is: canal re-excavation is necessary, but preferably not on my land). However the initial popular demand was strongest for canal excavation and re-excavation. Without excavation or re-excavation of khals, a proper water management system can not be developed. The construction of regulators without a proper link canal system does not contribute much to the expected benefits.

Land acquisition is a bottle-neck for the implementation of the project, as in most other development projects in Bangladesh. It takes 18 months to acquire land on average. With the district administration now being very cooperative, the time from proposal submission to land possession could be reduced to 12 months.

Lack of coordination between the CPP and local organisations had affected the integrated water management plan because the local organizations constructed their own interventions in the project area. A formal agreement for mutual consultation before the planning of any structural intervention will be made.

Necessary Government orders that would initiate and facilitate of inter-departmental cooperation, for the establishment of a local board of management and for local water management committees and groups, could not be obtained.

Flood Management Modelling provides significant enhancement in the understanding and visualisation of flood characteristics. It can simulate structure operation with sufficient accuracy to permit simple operation rules to be tested.
However, FMM needs a powerful computer system not yet everywhere available.

The testing of the water management system in the Tangail Compartment is very much nature dependent. The opportunity of partial testing this system in the compartment was lost because of the 'near dry' monsoon of 1994. The situation in 1995 will be even more unpredictable because of the recent closure of the northern intake of the Dhaleswari, the prime source of water for the Tangail Compartment. However, 1992 was a 'near dry' monsoon as well, so planning of testing of the water management system for a fixed year can not be recommended.

9 CONCLUSIONS AND RECOMMENDATIONS

An improved water management system in the Tangail Compartment will result in an increased rice production by improved drainage of rainfall and flood water and by reduced flood levels. The adverse effects on fisheries will be minimized by mitigating measures, such as fish friendly control structures. In the coming years the compartmentalization concept will be tested thoroughly in the Tangail area.

Local participation of beneficiaries has been promoted at all possible levels. The project consulted at least one out of three households of rural Tangail through needs assessment and consultant meetings. Peoples participation is most essential to make the project successful. Not only in this scheme.

Introducing integrated approaches is an irreversible process. CPP, among others, forms a test case as a catalyst or motivator and a means to make people become conscious of this process.

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Netherlands Experiences with Integrated Water Management (Proceedings of the meeting in Delft, The Netherlands, 5 October 1995)

THE NETHERLANDS CONTRIBUTION TO INTERNATIONAL EDUCATION AND TRAINING FOR THE WATER SECTOR

W. Spaans & W.A. Segeren

INTRODUCTION

Population growth and higher standards of life have resulted in a still increasing demand for industrial products, agricultural production, physical infrastructure, energy and water. Over-exploitation of earth non-renewable resources results in an irreversible depletion of minerals and ores, gas and oil, and geothermal energy. Over-exploitation of surface and groundwater basins, waste charges to surface water and leakage to groundwater leads to a rapid deterioration of water resources in quantity and quality. Proper management of earth resources - and of water in particular - is a prerequisite for a sustainable socio-economic and environmental development on a regional and global scale. Institutional and legislative frameworks are indispensable aspects for sustainable development. Complexity of both the physical and the administrative management system requires a multi-sectoral (horizontal) and inter-sectoral (vertical) integrated approach to water management.

Basic needs for such a water management infrastructure are:

- skilled personnel, from observer to planning director
- an efficient and well equipped administrative organization
- information tools like field and laboratory equipment, computer models, databases and geographic information systems
- access to up-to-date applied technology and consultancy.

Developing countries in general - even when having access to modern techniques - are lacking these skilled manpower, equipment and information technology. National and regional based training from vocational institutes to universities is the backbone for a sustained development in applied education and research.

Support by international institutes and internationally oriented universities substantially contributes to this development. Participation of technological institutes widen the scope of this international collaboration. Primary task of universities is the conduct of scientific educational and research programmes for nationally based students. The study leads to the BSc and MSc degree, while based on a sound scientific research the PhD degree may be obtained. International collaboration of Netherlands universities is mainly related to institutional strengthening of universities in developing countries and Central and Eastern Europe. The scientific and national oriented scope of universities and self-sufficiency in staff does in general not allow for a multi-disciplinary problem-solving approach which is needed for - in particular but not only - engineers from developing countries. Moreover university BSc, MSc and PhD programmes are difficult to access because of language, cultural and administrative barriers.

The orientation of water research institutes and consulting firms in general is more towards research and the execution of projects. Internationally orientated training programmes for technicians and research engineers are ad-hoc and restricted by their specific expertise and scientific scope. Their strength in international education is the contribution to conducting courses and support MSc and PhD research as conducted in the framework of post-graduate international education.

International education institutes offer tailored programmes in international education, training and applied research designed for strengthening of the water sector.
The most water oriented international education institute in The Netherlands is the IHE[1]. Other institutes with a water orientation are the ITC, ILRI and Wageningen Agricultural University, and to a lesser extend the IAC.

[1] See list of abbreviations at the end of this article

1 INTEGRATED WATER RESOURCES MANAGEMENT

Water is the most vital resource for mankind in:

- providing the basic needs for drinking water, sanitation and food production
- being the medium for aquatic ecosystems and wetlands
- stimulating socio-economic development of agriculture, industry, fishery, energy, transport, etc
- being a recipient for waste charges.

Water resources projects have a large impact on water resources, landuse, demographic developments, aquatic systems and public health. The still increasing water demand due to population growth and increase per capita due to higher socio-economic standards leads to the exhaustion of land and water resources. High abstractions result in depletion and desertification (quantitative). Increasing waste loads rapidly exceed the adsorption and regeneration potential (deterioration, qualitative). Poor water quality endangers life and health and increases the cost of supply and treatment.

Water as a non-economic good covers the basic human needs and is the medium of aquatic ecosystems. In a historical perspective water is often seen as a 'free product', but with increasing scarcity it is becoming more and more an economic good. Although cultural not always accepted, water pricing can become an effective measure to reduce the water demand and trigger the efficiency of distribution, treatment and re-use. And thus is a tool for Demand management. However, high pricing will most effect the poorest, and low pricing will not really trigger investment opportunities. Also here water resources management and water demand management go hand in hand.

In the framework of International Cooperation the water sector includes all water using activities like irrigation, municipal water supply and sanitation, waste collection and treatment, fishery and recreation, wetlands and other ecosystems. Large overlaps occur with sectors as Public Health, Agriculture and Fishery, Industry, Physical Infrastructure, etc.

Problems in water resources management can be summarized as:

- Increase in demand and waste production due to population growth and socio-economic development. In general there is a decrease in availability per capita, also in the rural areas.
  Urbanization leads to local depletion, pollution and demand for remote resources.
  Lack of employment opportunity triggers results in 'subsistence agriculture' resulting in the use of marginal soils and overgrazing and thus desertification and erosion.
  Deforestation leads to a change in micro climate and distribution of rainfall.
- Limited resources in combination with a sub-sectoral allocation orientation results in conflicting demands for the same resources and over-exploitation. This in turn increases salt intrusion, upconing of connate water and incessination.

- Quality deterioration due to exhausting of the self-purification potential. Industry produces large quantities of chemical and toxic waste. Inefficient irrigation practices increase the need for fertilizers and pesticides, where inadequate drainage results often in salinisation of the top soil. Waste water collection and treatment is lagging behind due to non-awareness and high investment costs.
- 'Cheap' water results too often in inefficient water use. The farmer is not triggered to invest in more efficient methods (drip irrigation) or the production of precious crops. A poorly maintained irrigation system yields extra losses. Food security of countries allows the production of low-economic crops. Historical water rights also create a sub-optimal use: upstream farmers receive too much, tail-end farmers too little. Low profit of municipal water supply companies does not stimulate a good maintenance and investment. An additional complication occurs when the government receives the revenues and pays the water company on a marginal base for the operation and maintenance costs.
- It matters who benefits and who pays. Large scale projects used to lack a proper socio-economic and environmental assessment. New reservoirs serve larger command areas but force migration of people, large groundwater abstractions serve water users but also induce aquifer deterioration by lower water tables and induced pollution.
- Curative measures like compensation of damage (incessination, contamination, eco deterioration) or rehabilitation of ecosystems afterwards is more costly than taking preventive measures.

There is an apparent need for well established waste water management and environmental pollution control, which is based on a sound socio-economic assessment and justification.

In a broad context water management focuses on:

- Physical aspects. The relation between quantity and quality (availability) and biological processes in groundwater and surface water, and the long term sustainability of man-effected natural ecosystems.
- Sectoral aspects. Water management goes beyond sub-sectoral projects and requires inter- and multi-sectoral tuning of water availability versus demands and waste production, based on an overall social and economic justification.
- Institutional aspects. Top-down master planning and legislation versus bottom-up community participation and project coordination.

An integrated approach to water resources development projects and studies should be:

- multi- and inter-sectoral in approach
- considered as being part of the overall physical system of a river basin or catchment (surface water) or aquifer system (groundwater)
- social and/or economic feasible, or serving the direct needs for environmental protection and poverty combat
- embedded in an institutional and legislative framework.

2 THE NETHERLANDS SUPPORT TO THE WATER SECTOR

Some 20% of the expenses of The Netherlands Government support during recent years are in the water sector: drinking water and sanitation (50%), agriculture (20%), water management and studies (20%), transport and fishery (10%), focusing on countries like India and Bangladesh; Egypt, Yemen and Sudan; Kenya, Burkina Fasso and Mozambique, with a major emphasis on groundwater availability and recommended measures.

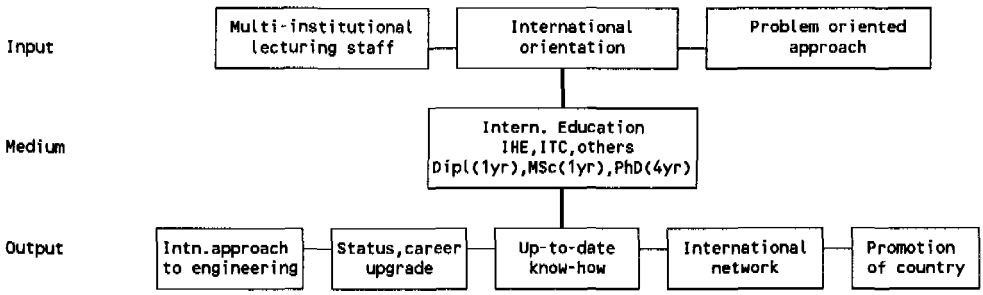
Bottleneck in almost all studies and projects is the implementation and functioning of the related administrative and organizational framework. A sub-sectoral project approach often creates conflicting interests, like between irrigation and drinking water (Yemen), water storage and environment (Egypt) and polder development and social interests (Bangladesh). At present all water projects are subject to environmental assessment. Construction projects in general lack adequate operational management and maintenance, due to absence of managing institutions and lack of financial triggers with the executing institutions.

Examples of Integrated Planning and Management are the Flood Action Plan (Bangladesh), Water Resources District Planning (Kenya) and the Water Resources Assessment Study (Yemen). Spearhead is the implementation of Integrated WRM in experimental river basins. Environmental profile studies are supported in Yemen, Gaza and Baluchistan

2.1 International education

Transfer of knowledge involves next to technology also institutional, organizational and legislative aspects. Resources and demand management (pricing, awareness, incentives) are integrated items of this transfer.

International Education (IO) institutes have a specific international oriented scientific approach to applied research and education. Their set-up allows to offer a wide range of post-graduate training programmes in the fields of earth sciences, (integrated) water management, agriculture and institutional development. The involvement of lecturers from technical institutes, consultants and universities from all over the world safeguards an international applied problem oriented approach to education and research. It is the involvement of a variety of institutions and disciplines which makes these IO institutes unique in its international approach to education, research and capacity building.
Post-graduate diploma and MSc courses are practical and orientated toward problem solving and is designed for BSc holders with a relevant working experience. The duration of one year for diploma courses and a maximum of 16-20 months for MSc courses allows a quick return to the job and prevents from brain drain. PhD studies in general have a duration of four years. In principle the PhD programmes are of the 'sandwich' type where a substantial part of the research is done in the home country.The input-output relation of IO post-graduate training can be schematized as:



Two major IO institutes in The Netherlands - which jointly cover training, research and advisory services in the field of earth sciences, water resources and integrated management - are the International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE) and the International Institute for Aerospace Survey and Earth Sciences (ITC). The Wageningen Agricultural University conducts MSc courses in Agricultural Demand and Management and Environmental Sciences. The International Agricultural Centre (IAC) and the International Institute for Land Reclamation and Improvement (ILRI), Wageningen, conduct short course programmes on water, land and environmental management and provides advisory services. Velp Polytechnic offers an international MSc course.

3 WATER RESOURCES MANAGEMENT EDUCATION

Sustainable management and development of water resources involves a number of distinctive steps from data collection to institution building. The various activity stages in the framework of water resources -physical, socio-economic and institutional systems- can be described as:

Physical system Survey	Geology, Hydrology, Environment, Ecology, Plant-soil-water Exploration and Remote sensing techniques
Physical Information Management	Databases, Geographic information systems (GIS) Computer graphics
Physical Simulation Prediction	Modelling flow, pollution, ecosystems River and reservoir simulations
Water Engineering	Allocation and collection methods, irrigation, (waste) water Exploitation techniques, resource manipulation
Socio-economic	Feasibility, pricing, social impacts Production input-output models
Decision Making	Economic, Social and Environmental assessment Multi Criteria Analysis
Management Legislation	Institution building, Manpower development Inter-sectoral organization and legislation

A prerequisite for the execution of this overall framework is a well structured organizational and administrative framework. In turn this needs a well-founded internationally oriented educational framework in water resources, which in IO respect is covered by the ITC, IHE and others:

	ITC	IHE	IAC/ILRI
Physical Systems Survey	▬▬▬▬▬▬▬▬▬▬▬	▬▬▬▬▬▬▬	▬▬▬▬▬▬▬▬
Physical Info Systems	▬▬▬▬▬▬▬▬▬▬▬▬	▬▬▬▬▬▬▬▬▬	▬▬▬▬
Physical Simulation	▬▬▬▬	▬▬▬▬▬▬▬▬▬▬▬▬	▬▬▬
Water Engineering	▬▬	▬▬▬▬▬▬▬▬▬▬▬▬	▬▬▬▬
Socio-Economic	▬▬	▬▬▬▬▬▬▬▬▬	▬▬▬▬▬▬▬▬▬
Decision Making	▬▬▬▬▬▬	▬▬▬▬▬▬▬▬	▬▬
Management/Legislation	▬▬	▬▬▬▬▬▬▬	▬▬▬▬▬▬▬▬▬

3.1 Institutional strengthening

International technical cooperation in the field of water and environment used to concentrate on the realization of engineering projects for groundwater and surface water development to satisfy agricultural (irrigation), municipal and industrial water requirements. Justification was mainly based on economic feasibility and strongly triggered by public opinion. In the early eighties more attention was given to sanitation and public health projects regarding water treatment, water distribution, and waste water collection. Here also economic and general social aspects were decisive in its justification. Social and environmental awareness together with community participation became vital items in project justification during the late eighties. Early nineties integrated water resources management became the central item, merging quantity and quality, and with emphasis on legislation, administration and strategic planning.

Transfer of knowledge through training and education, workshops and seminars, publications and pilot projects became a spearhead in sustainable institutional development. Substantial efforts have been and still are being made by bilateral, multi-lateral and international donor organizations and implementing institutions and universities. However, this has not really resulted in well established knowledge units embedded in the ministries, authorities, institutes and universities to safeguard a sustained support in - and development of - local know-how of the design, construction, operation and management of water resources systems.

Institutional strengthening and human resource development is now given top-priority by most international development institutions, including the World Bank and UN organizations. This institutional strengthening involves capacity building on skilled manpower, organizational and administrative support, technical management and continuous education at various levels:

National	Ministries, authorities involved in water sector master planning; Universities for education and applied research.
District	Councils and water companies involved in regional planning and development; Vocational training centres for high/mid level technician training.
Local	Local councils and projects involved in local planning and operation; In-service training in the projects, and community participation.

Human resources development from mid-level technician to senior university researcher within the framework of continuous education and dissemination of knowledge involves:

-	On the Job training Vocational training	In-service and abroad, for operators and high level technicians
-	Specialization programmes	Workshops, seminars, short courses Role plays
-	Dissemination of knowledge	Symposia, publications, manuals, newsletters Refresher courses for alumni
-	Post-graduate and MSc courses Research and PhD programmes	In-country by universities Abroad mainly by IO institutes
-	Educational capacity building programmes	In-country, supported by universities and IO institutes

3.2 On the job and vocational training

On the job training involves practical training in the day to day work activities of mid-level and high-level technicians. In-service training is done by (expatriate) experts and devoted to a limited number of staff. Depending on the specific activity this training has a duration of one month to several years and is in general labour intensive. Often the upgraded staff obtains a better position elsewhere and is no longer beneficial for the project. Highly specialized training for promising staff can be given at specialized institutes or by authorities abroad. Only in rare cases on the job training is devoted to graduate staff. Examples are training in hydrological observations, network loss determination, workshop management and computer data manipulation.

Usually training abroad is offered at specialized water boards and technological institutes like the Caribbean Meteorological Institute, Barbados. The ITC Diploma Course in Cartography is the only Netherlands regular technician course.

Vocational training is devoted to mid-level and high-level technicians. The training has a duration of two to three years and is on a regular base conducted at national or regional vocational training centres. Foreign support can be given by experts from technical colleges and water authorities. Examples are a training of geo-hydrological observer, workshop manager and geophysical operator. The DGIS financed and NUFFIC based 'Financing Programme for Cooperation in Higher Education' supports this higher education of technical and professional staff.

3.3 Specialization programmes

Specialization programmes are devoted to specific problems in water resources management. The course programmes can be conducted worldwide and include problem oriented lectures in combination with hand-on practical workshops, role plays and fieldwork. These programmes are being carried out on a 'open registration base' at the request of an international organization or 'tailor made' at the request of a national authority or government. Depending on the target group the set-up of the programme will be:

- course oriented with a substantial number of lecturing hours
- workshop oriented with a major emphasis on hands-on exercises
- fieldwork oriented, devoted to field investigations and their interpretation
- seminar oriented, where participants and invited experts present and discuss the specific topics.

The duration ranges from 1 week for seminars to 2 months for fieldwork oriented courses. Examples of tailor made courses are the courses on agricultural and rural extension of the IAC and a six weeks course on Environmental Impact Assessment for the Environmental Protection Agency of Taiwan (IHE). The Short Course Programmes in Groundwater Modelling and Management as jointly conducted by the IHE and the Institute for Applied Geosciences (TNO-IG) in Delft illustrates the 'open registration' courses. Although tailored to the top-of-the-art, the programme also includes a six week summer-course on Groundwater Modelling and Management for Developing Countries.
A particular case is the two months course on Hydrogeology and Groundwater Modelling - jointly by IWACO consultants and the IHE - in the framework of a series of training courses on water related issues, implemented by the Multilateral Working Group on Water under the Middle East Peace Process, and sponsored by DGIS. This course has been conducted in Oman and Delft and aimed at water engineers from Palestine, Israel, Jordan, Egypt, Oman and Yemen.

3.4 Dissemination of knowledge

This involves the 'public domain' aspects of transfer of knowledge and includes:

- Symposia and conferences which deal with specific topics. Examples are the ICID conferences and the Symposia on Hydro-informatics.
- Expert meetings as organized by international associations like IAH, IAHR and IHE/IGWMC.
- Public guest lectures, addressed in a 'Studium Generale' or at other events.
- Proceedings of the above mentioned meetings and symposia.
- Books, technical publications and lecture notes as distributed by ILRI, IHE, ITC, universities and others.
- Articles in technical periodicals as the Journal of Hydrology, Water Resources Research and Agriculture.
- Handbooks and fact sheets on specific topics as published by FAO and as planned by the IAH.
- Newsletters, information bulletins and annual reports from institutions and companies.

3.5 Regular post-graduate and MSc courses on water management

Post-graduate international education in The Netherlands is accessible for mid-career BSc holders from predominantly developing countries. Conditions for approval are a proven working experience in the field of study, a BSc degree in engineering or earth science and financial support. As mentioned earlier, international post-graduate diploma and MSc education in water and related disciplines is covered by IO institutes:

- The International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE), Delft.
  In the wide field of water resources and environment the IHE organizes one year post-graduate diploma courses in Hydrologic and Hydraulic Engineering, Sanitary and Environmental Engineering and Water Quality Management and Ecology. Out of the 300 annual participants, over 250 are enroled in water related courses. Successful students can be admitted to the six months MSc programme.
- The International Institute for Aerospace Survey and Earth Sciences (ITC) based in Enschede and Delft.
  In the field of water resources and environment the ITC offers post-graduate and MSc courses in Environmental System Analysis and Monitoring, Natural Resources Survey, Exploration Geophysics and Engineering Geology. Out of the 300 annual participants some 50 follow the water resources related specializations.
- The Wageningen Agricultural University (WAU).
  In the field of agricultural production and management the WAU offers MSc courses in agricultural, soil and water, environmental and aquacultural management, as do the International Agricultural Centre and the International Institute for Land Reclamation and Improvement, Wageningen. The International Polytechnic Larenstein (Velp) offers an MSc course in water management.

The post-graduate diploma and MSc courses are conducted by internal staff, supplemented by experts from national and international universities and scientific institutes. The MSc programmes are supervised and evaluated by both internal and external senior staff.

4 EDUCATIONAL SUPPORT OF THE NETHERLANDS GOVERNMENT

For the water sector the Netherlands Government priorities are on the effects of water resources projects on the environment, participation of women and poverty combat. The strengthening of education and training is a spearhead activity. Education in integrated water resources involves tuning and even merging of educational programmes at all levels and for all disciplines, relevance with respect to the training demand of skilled personnel and triggering the cooperation between state and private educational institutes.
Training programmes for Institutional strengthening can be realized by:

- long-term bilateral educational projects (DPO/IO)
- 'earmarked' contributions to specialized UN institutions like UNESCO, IIEP/UNESCO and multi-lateral projects
- training of people responsible for educational planning, policy development and management.

The Netherlands contribution to this higher education is financed by the International Educational Programme of DGIS.

4.1 International education projects programme (IOP)

This DGIS/DPO/IO programme aims at long-term educational and training contacts between institutes in developing countries and International Education Institutes in The Netherlands. In exceptional cases other Dutch institutes can participate, but universities and polytechnic are excluded. The IOP programme aims at:

a) Institution building. Support to educational and training institutes in developing countries by sponsoring new educational programmes, updating and implementing curricula, developing educational materials and tools, staff support and joint education-related consultancy activities.
b) Human resources development. Training of trainers in educational, training, research and consultancy capacities by
   - additional training in the country or abroad
   - provision of grants for courses organized by the cooperating institute.
c) Strengthening non-educational institutions with established training programmes and facilities, including the managerial level.

4.2 Direct support programme to training institutes in developing countries (DSO)

This direct funding focuses on regional cooperation by:

a) Institution building of educational and training institutes by financial support of the in-country training potential. Aiming at curricula development and lecturing materials, education-linked research and staff exchange.
b) Training capacity building by additional staff training, grants for participants in regular courses of IO institutes.
c) Technical cooperation between educational and training institutes of developing countries (South-south cooperation). Realized by exchange of staff and materials, joint curriculum implementation and staff training, and the provision of management consultancies.

4.3 The Netherlands fellowships programme (NFP)

The Programme for International Education aims at human resource development in developing countries. One aspect of this programme is the NFP which focuses at training in The Netherlands for mid-career employees of governmental organisations, educational institutes, NGO's, etc. Post-graduate courses have a duration of around twelve months and participants have a minimum working experience of three years. Some courses also include the Master programme and in some cases the PhD programme.
The so-called Regular International Programmes are organized by some fifteen institutes, organized in the Federation of IO institutes in The Netherlands (FION). Related to the water sector these institutes are IHE-Delft, ITC-Enschede/Delft, Wageningen Agricultural University, ILRI-Wageningen and the IAC-Wageningen. These institutes are autonomous in the acquisition, selection and granting of fellowships. Overall funding and planning is the responsibility of DGIS, together with a priority setting for countries and target groups.
Candidates for a regular fellowship must have a working experience in the field of the study, the age limit is 40 (males) and 45 (females). They are nominated by their employer, formal employment must be continued during and beyond the fellowship period. Applications are channelled through the local Netherlands diplomatic mission to the IO institute in The Netherlands. Revision and implementation of new courses need the approval of DPO-IO.
Tailor made or ad-hoc courses can be organized for individuals or groups, serving a specific training need. They can involve individual placement with a company, IO-institutes, universities and other institutions. The fellowship procedure is the same as for regular courses.

4.4 Joint financing programme for academic cooperation (MHO)

This programme focuses on:

- institution building of universities and polytechnic
- supplementing of skilled high level personnel.

Long-term institutional strengthening of educational, training and research capabilities is to be realized through cooperation between universities and polytechnic in The Netherlands and a developing country. Cooperation includes technical, didactic and institutional management aspects, and logistics. Prerequisite is future self-support of the implementing organization. The NUFFIC is the organization in charge of implementation and monitoring.

5 NETWORKS FOR THE WATER SECTOR

5.1 Geoneth

International training and research for sustainable water resources development, aiming at supply and demand management and rural land use planning, requires an inter-institutional approach. Geoneth is a cooperative association of research, information and training institutes, university institutions and government agencies in The Netherlands. Geoneth applies and extends the specific Dutch knowledge and experience on a world-wide basis in the broad spectrum of geosciences. Major joint activities are:

- human resources development and capacity building through education and training
- technical assistance and advisory services.

IHE, ITC and IAC are here the leading institutes for regular and tailor made post-graduate and MSc education and capacity building. Specific research and training projects of the various universities and institution supplement this contribution.

5.2 ARMADA

The newly established 'Aquatic Resources Management and Development Accord' is an initiative of several European universities and research institutes. Main aim is to provide applied post-graduate training and problem oriented research in aquatic resource management. This includes a framework for coordinated research in and with developing countries. Research and PhD studies are to be carried out in a sandwich construction. The IHE is here the leading partner.

5.3 Research school for hydraulic engineering

Aims at joint research and PhD programmes in Integrated Water Management, Design and Construction, and Physics of Soil and Water. The coordinator is the Technical University Delft (TUD). Other members are the IHE and the Universities of Utrecht and Twente. Associate members are the RIKZ, RIZA, Delft Hydraulics, Delft Geotechnics and DWW.

5.4 Research school for hydrology and environment

Aims at joint research and PhD programmes in hydrology and water resources. Here the coordinator is also the TUD, other members are the IHE, ITC, Universities of Groningen and Utrecht, Free University of Amsterdam and the University of Wageningen.

6 INTERNATIONAL EDUCATION SET-UP

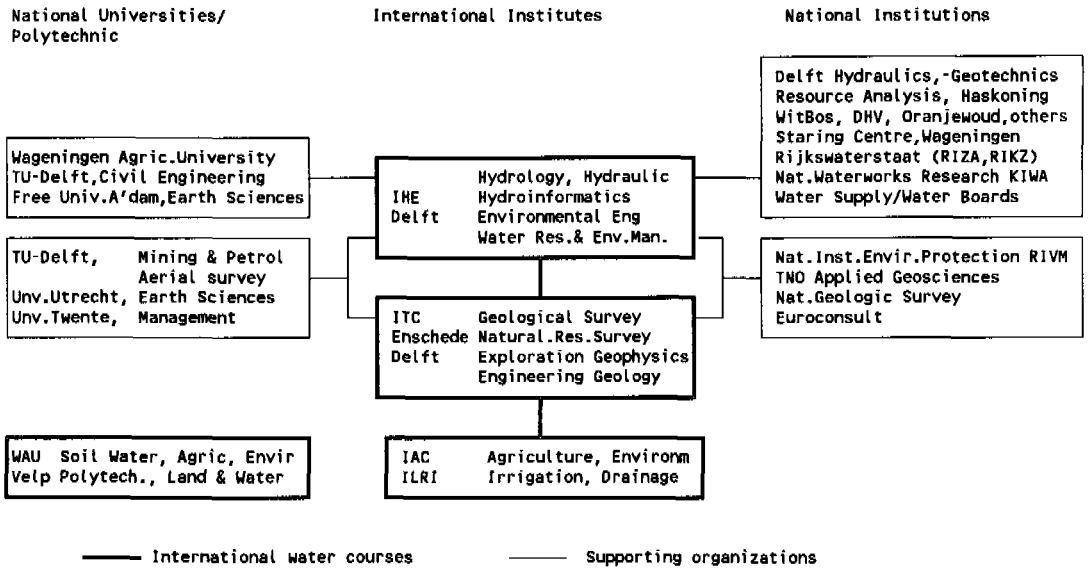
6.1 IHE course organization

Post-graduate integrated water resources and environmental management education at the IHE is organized within two main scientific departments, Hydraulic and Hydrologic Engineering (HH) and Environmental Engineering (EE). The courses with a major orientation on water are Groundwater Hydrology, Water Resources Management and Surface Water Hydrology. The course on Water Resources and Environmental Management is newly developed for planners. Water supply and distribution, rural development and waste water management are part of the sanitary course programme, and ecology and wetland development is part of the environmental oriented courses. All courses include social-economic, environmental and institutional topics. To a limited extend there is an overlap between the various courses. The one year Diploma Courses are subdivided in two terms. The first term is mainly devoted to basic and applied subjects which are presented as lectures and related practical exercises and computer workshops. Major subjects are examined. The core of the second term is group work where in a stepwise interactive approach an engineering design or masterplan is developed. During this term the lecturing programme consists of both compulsory and elective specializing subjects. A three week field programme is part of the programme. The final evaluation of the participant is based on the results of the examinations, the individual performance in the group work and a general final examination. On successful completion the Post-Graduate IHE diploma is awarded. Participants with a good study performance - average examination mark higher than 7.5 - are admitted to the MSc programme. This programme has a duration of six months during which a sound piece of applied research should result in the presentation of a thesis. The research work is evaluated by internal and external professors and the Master of Science degree is awarded.
The lecturing programme at IHE is conducted by some 80 internal IHE and some 450 external lecturers.

6.2 ITC course organization

The relevant course programmes include Natural Resources Survey, Applied Geomorphology and Engineering Geology, and Exploration Physics.
The set-up of the ITC post-graduate and MSc courses is comparable to the IHE courses. Major differences are that admission to the MSc programme is decided at the start of the study and the inclusion of a lecturing cluster in the MSc programmes.
The one year diploma course programme consists of two terms, the first term of four months being devoted to remote sensing, mapping and refresher subjects. The second term of seven months includes four months of specific course-related subjects and three months of fieldwork. The MSc programme has an additional duration of eight months, and includes a specializing lecturing programme and the presentation of a thesis or project work.
The lecturing programme at the ITC is mainly conducted by internal staff and a limited number of guest lecturers from universities and scientific institutes.

International water resources education in The Netherlands. National links and involvement



6.3 IAC and ILRI course organization

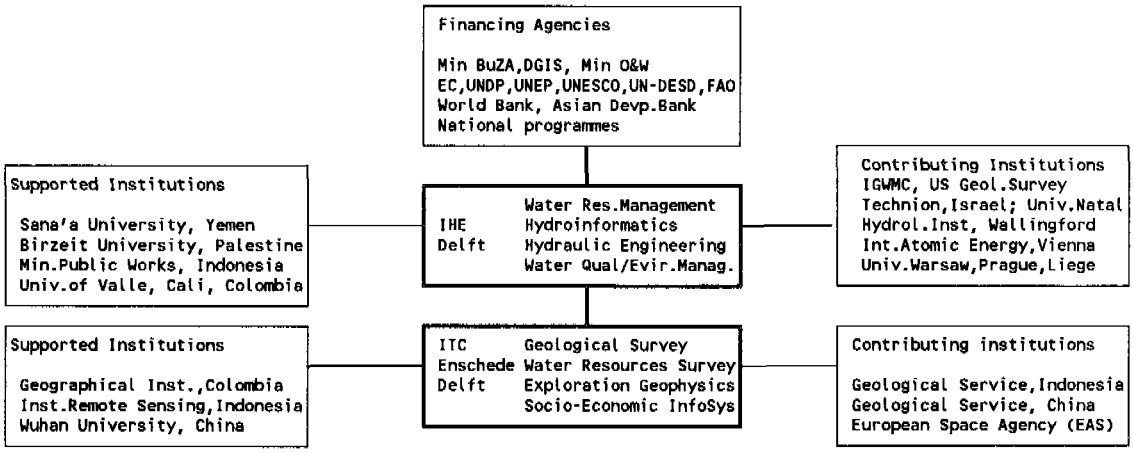
Relevant courses of the IAC to the water sector are courses on crop production and land use planning. The course programme is of limited duration and to a large extend of a tailor made structure. A large part of the water related activities consist of advisory services by the Land and Water Unit.
The ILRI conducts short courses on Land Drainage and Land and Water Development. A course on Computer Applications in Irrigation is conducted jointly with the Institute of Irrigation Studies, University of Southampton. In collaboration with the IHE a specialization course on Appropriate Modernization and Management of Irrigation Systems is conducted.

6.4 PhD programmes

Research programmes as well as advisory services are essential for strengthening the institutes expertise and safeguard the quality of the continuously changing educational programme. Traditionally PhD research programmes are conducted at universities. Recently ITC and IHE have introduced PhD research programmes in cooperation with universities in The Netherlands and abroad, and institutes in developing countries. Often these programmes, with a minimum duration of three to four years, are conducted in a sandwich construction where the field research and preliminary report writing is done in the country and the actual thesis is prepared in the donor country.

Examples of PhD research programmes are sustainable use of arid and semi-arid zones, decision support systems for groundwater management, and effects of large scale human interference on micro-climate and environment.

International relations in water management at the IHE and ITC



6.5 Institutional and educational capacity building

National university and post-graduate education programmes are prerequisites for a sustainable development of a country or region, together with institutional strengthening. The IHE and ITC, as well as national universities, conduct capacity building programmes for the strengthening of the educational and research nucleus at universities all over the world. Technical research institutions like TNO-Geosciences, the IO institutes IHE and ITC, water authorities and private consultants conduct institutional strengthening for ministries and authorities in developing countries.
An illustrative project on institutional strengthening and human resources development is the IHE project line for Palestine which started in 1992:

- A two-years training and institutional strengthening programme for Birzeit University, Westbank. Post-graduate courses in water resources management, water supply and environmental sanitation were conducted to strengthen some 70 Palestinian professionals in planning, design and management.
- A short course on Strategic Action Planning and Project development.
  Participation in a seminar on 'Doing Business with Palestine.
  Participation in the Working Group for Environmental Impact Assessment of the Gaza Port.
- Rafah Solid Waste Disposal project.
  Gaza City Solid Waste Disposal project.

- Specialist training of Palestinian professionals in Sanitary engineering, water resources management and water quality management at IHE-Delft.
- *Project document for Capacity building in the Palestine water sector*, Birzeit. Project document for Physical Planning of the Gaza strip.
- Middle East Training course on Hydrogeology and Groundwater Modelling, jointly by IWACO and IHE, Muscat and Delft.

Among the many ongoing projects are the collaboration programmes of the Free University with the Wuhan and Beijing Universities of Geosciences (China, staff exchange) and Western Cape University (South Africa, research and training)), the ITC support programmes with Colombia, Indonesia and China. Other examples are the programmes of the IHE with the Sana'a University (Yemen), the Ministry of Public Works (Indonesia), the Hydraulic Research Institute (Egypt), and the University de Valle (Colombia).

6.6 A strategic view on international education

In future developments on international education and research even more emphasis shall be laid on Integrated Water Resources Management, with emphasis on inter- and multi sectoral approach. Next to physical and socio-economic aspects, institution building, human resources development and frameworks for legislation and organisation must form an integral part of the training programmes. Emphasis must be laid on Resources management, Demand management, Who benefits-who pays, Environmental and ecological assessment, Environmental profiling, and Socio-economic assessment and justification.

Networking and active participation of experts and policy makers from both developed and developing countries in the educational, training, research and institutional programmes is a prerequisite for a log-term sustainable cooperation. Merging knowledge and experience will support the self reliance of countries and benefit all parties involved.

Establishment of Centres of Expertise on national and regional level must be promoted. These nodal networks will be the spider in the web or network of national and regional programmes and institutions, and the essential link to universities and research institutes. In this context joint research and educational programmes will be conducted. They are also the corner stones for institutional strengthening, human resources development and country assessment programmes. On a structural basis these centres employ foreign experts from all over the world. Exchange programmes between these centres and IO institutes is just another logical step in this development.
Lacking basic elements of capacity building are:

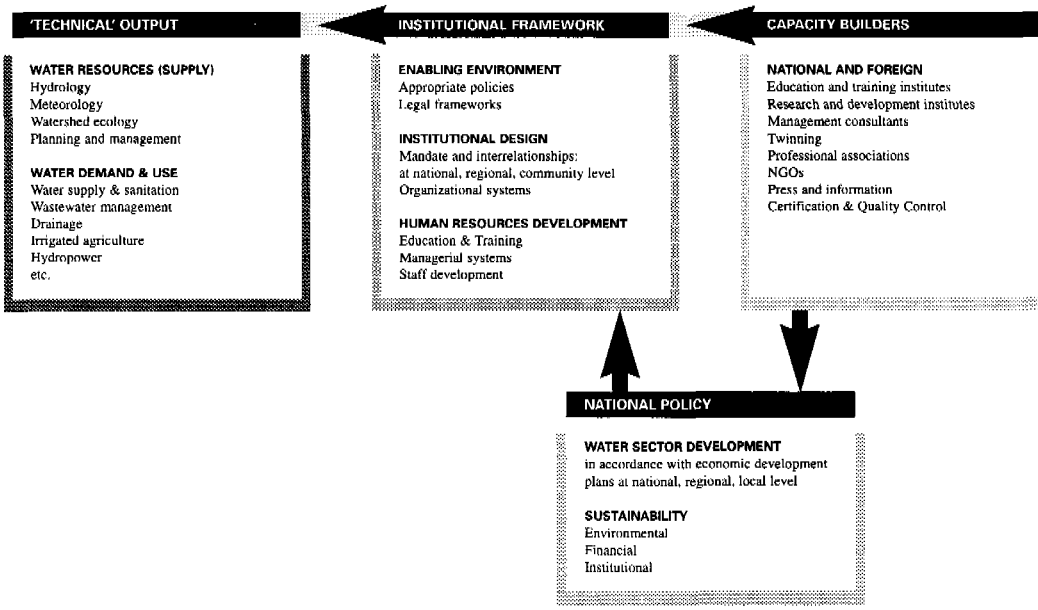
- an environment enabling the
  - socio-economic founded policy and decision structure
  - framework for legislation
- institutional development (inter- and multi-sectoral)
  community participation (bottom-up)
- human resources development and a management system.

International education and networking by means of national or regional Centres of Expertise are most appropriate tools for realizing or channelling these training needs, as these centres are embedded and accepted by institutional interest groups and governments.

Capacity strengthening in the water sector distinguishes four levels of involvement:

1 Requested output. Plans and projects are triggered by the demand, expressed in a technical output.
2 Interventions. The water sector and other sectors are involved in tuning, justification (sustainability) and feasibility (execution, O/M) of these plans and projects.
3 Institutions. Tuning of responsibilities and mandates at all levels, being the base for a sound and structured policy making within a legal framework. Planning of human resources development is a logical spin-off.
4 Capacity builders. All international and national institutions have a role in training, research, management and twinning to realize an optimal communication and tuning of decision making and management.

Their interactions are illustrated in the scheme below.



7 SYNTHESIS

The core of international transfer of knowledge and education for developing countries is largely based at the IO institutes like the IHE and ITC. The IAC and ILRI offer courses of a relatively short duration on agricultural development.Links with national and international educational and research institutes are indispensable for the conduct of a sustained educational and applied research programme. The Netherlands IO programme is one of the important supporting agencies to the realization of international institution building for the water sector.

Scientific educational and research institutes strengthen the IO activities. Technological institutes and consultants complement the field of training and institutional strengthening for the water sector in developing countries.

The activities can be summarized as follows:

Institution		IO Activities
Tech. Univ. Delft Free Univ. Amsterdam Univ.Utrecht Agric.Univ.Wageningen	Dept.Civil Eng Dept.Mining Dept.GeoSciences Dept.Earth Science Depts.WQM, WRM and Soil Sciences.	University capacity building PhD programmes Guest lecturing IHE,ITC Dissemination of knowledge Short specialization courses MSc programmes (Wageningen)
IHE-Delft ITC-Enschede,Delft	Water Resources Hydraulic Engineering Hydroinformatics Sanitary & Environment Aquatic Ecology,Wetlands Water Resources Survey Engineering Geology Socio-economic Info	Post-graduate courses MSc and PhD courses Specialization courses Institutional strengthening Dissemination of knowledge Guest lecturing
IAC,ILRI Wageningen		As IHE-ITC, but no MSc-PhD and courses of short duration
Rijkswaterstaat, various TNO-Geosciences, Delft Staring Centre, Wageningen Nat.Inst.for Envir.Protection (RIVM), Bilthoven Nat.Geological Survey (RGD), Haarlem Nat.Inst.for Water Supply Research (KIWA) Delft Geotechnics, Delft Hydraulics		Institutional strengthening MSc,PhD support and superv. Guest lecturing ITC, IHE Dissemination of knowledge In-house training
IWACO,DHV,Euroconsult,etc Delft Hydraulics,Resource Analysis,etc Nethconsult (BKH, WITBOS, etc) Water/waste water companies, water boards		In-service training MSc supervision Guest lecturing Dissemination of knowledge

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Facts and figures, Annual reports IHE.

Annual reports ITC, IAC, ILRI.

LIST OF ABBREVIATIONS

BuZa	The Netherlands Ministry of Foreign Affairs, The Hague
DGIS	Directorate General for International Cooperation, BuZa, The Hague
DPO	Department of Projects and Education
DWW	Rijkswaterstaat, Civil Engineering Department
FION	Federation of IO Institutes in The Netherlands
IAC	International Agricultural Centre, Wageningen
IHE	International Institute for Infrastructural, Hydraulic and Environmental Engineering, Delft
ILRI	International Institute for Land Reclamation and Improvement, Wageningen
IO	International Education
NUFFIC	Netherlands University Foundation For International Cooperation, The Hague
MSc	Master of Science degree
PhD	Doctor degree in Philosophy
RIKZ	National Institute for Coastal and Marine Management
RIVM	National Institute for Hygiene and Environmental Protection
RIZA	Institute for Inland Water Management and Waste Water Treatment
RUG	State University Groningen
RUU	State University Utrecht
TUD	Technical University Delft

INTERNATIONAL FINANCING

Financing of international education and research is done by many institutions by means of:

- direct subsidies and donation to educational institutions
- providing fellowships for study and research in the region or abroad
- direct financing of total projects or of the educational component
- supporting dissemination of knowledge.

Relevant financing institutions in the Dutch IO framework are:

The Netherlands Government
Min.Foreign Affairs, DG.Int.Cooperation (DGIS): DPO and Country desks
Min.Education and Science and Economic Affairs: NUFFIC
Min.Housing, Physical Planning and Environment

Commission of the European Communities (EC)
European Development Fund for Africa, Caribbean and Pacific
EC-Asian Fellowships Programme
South Africa Fellowships programme

Bilateral organizations of Germany (GTZ), Denmark (DANIDA), US (USAid), etc.

United Nations and other Fellowships programmes
UN Educational, Scientific and Cultural Organisation (UNESCO), Paris
UN Development Programme (UNDP), New York
UN Food and Agricultural Organization (FAO), Rome
UN International Atomic Energy Agency (IAEA), Vienna
UN World Meteorological Organization (WMO), Geneva
UN World Health Organization (WHO), Geneva
UN Centre for Human Settlements (UNCHS), New York
UN Environmental Programme (UNEP), Paris

Int.Bank for Reconstruction and Devp / World Bank, Washington, USA
Asian Development Bank, Manilla, Philippines
African Development Bank, Nairobi

Netherlands Experiences with Integrated Water Management (Proceedings of the meeting in Delft, The Netherlands, 5 October 1995)

EXPERIENCES IN INTEGRATED WATER MANAGEMENT IN THE NETHERLANDS AND ABROAD

A. Leusink

ABSTRACT

The closing session of the symposium consisted of an interview with Mr. E.H. Togtema, President of the Waterboard of Friesland, who is administratively engaged with recent developments in water management in the Netherlands and with Dr. F.R. Rijsberman, Director of Resource Analysis, who advises on water management issues in the Netherlands and abroad. The following summarizes the main issues which were discussed.

1 INTRODUCTION

Since early times, all over the world people organize themselves to exploit the natural resources more efficiently. It implicates that in an ever increasing rhythm these resources are over-exploited and have led or are leading to conflicts between interest groups. Water is one of these resources and until recently has been taken for granted in many regions. For thousands of years people in semi-arid regions have fought for the water rights of some areas or for the ownership of wells, which were essential for their survival.

Until a few decades ago and in some areas up till recently the policy has been that water demand should be fulfilled. Water use should not be restricted. It was a challenge for engineers to comply with demand and explore new resources. This policy however has been abandoned in most industrialized countries. Water of good quality has become a scarce resource which has to be managed well to make it available at the right place with an appropriate quality and in a sustainable way.

In the past most attention was focused on water resources assessment and development. High investments were made in physical measures to explore the surface and groundwater reserves and to make them exploitable. During this phase large dams for surface water and well fields for groundwater were realised and the water is transported over long distances by open canals or pipelines.

Now we are entering the period of the maturing water economy, with increasing competition for access to fixed supplies, a growing risk of water pollution and sharply higher economic, social and environmental costs of development. The shift is from a supply orientation to emphasis on demand management.

2 DEMAND MANAGEMENT

Besides price-based incentives to conserve water, demand management includes educational, technical and administrative programmes. Often these are used together with price incentives to conserve water and thus limit the need for new supplies. The importance of pricing and other incentives that encourage consumers to adopt efficient water use practices depends on the relative value of the water. When good quality water is plentiful, the willingness for efficient water use is low. However, it becomes increasingly worthwhile to measure, monitor and price water carefully as it becomes scarce. In many areas of the world, underpricing has caused serious misuse of water. In particular, agriculture, which absorbs the greater part of water, often includes low-value uses per cubic meter compared with higher value domestic, industrial or even natural uses.

Collection of fees is a major problem in developing countries. Often the authorities cannot break through a vicious circle: due to lack of proper maintenance and reliable delivery consumers are reluctant to pay their fees with as a consequence an insufficient operational budget for the authority. Then restructuring of public service agencies into financially

autonomous entities is a prerequisite for effective water management. Currently the World Bank is strongly promoting privatization in the water sector.

As water scarcity and waste disposal problems become more acute, it will become increasingly important to adapt and improve water conservation practices. Conservation might involve:

- reducing distribution losses
- reducing evaporation of storage reservoirs in semi-arid regions
- practising water-efficient irrigation techniques
- adopting water-efficient technologies, such as water-conserving shower heads and toilets
- water users changing their habits
- improved sewage treatment and use of waste water for non-potable purposes
- 2-way water distribution and waste water collection system.

3 WATER ALLOCATION

Important elements in any strategy to conserve water are the incentives for adopting technologies and management tools that increase the efficient use, allocation, and distribution of water. In their paper Huisman and De Jong present the history of the organizational structure of water management in the Netherlands. Through the ages the number of interest groups increased and the role of the human activity system became primordial. Now the question arises how to allocate the available resources to the different users: drinking water supply, industry, agriculture, nature, navigation, recreation, fisheries, flushing, cooling and which constraints are to be encountered.

Main criteria for comparing alternative institutional arrangements to re-allocate water are:

- flexibility in allocating supplies in response to both short-term and long-term changes
- security of the rights of the water users to encourage investment in and maintenance of water using systems while allowing for users to respond voluntarily to incentives to re-allocate supplies
- the degree in which the user is confronted with the real opportunity cost of water.

Masterplans for water resources management often indicate specific user functions to the surface water resources in hydrological entities or administrative units. The water authorities should levy charges on the water users for flood protection and drainage, the consumption of drinking water, water use for agriculture and the treatment and disposal of waste water. Frequently these charges are replaced by unit rates and do not reflect the actual water use or pollution loads of the individual users.

An important issue concerning the costs of water development works is the probability of occurrence of an event. This counts for high floods in a river, high waters and storms at

the coastal zone, drought conditions and peak water consumption. The degree of socio-economic development of a country determines the acceptability of the occurrence of harmful events.

In some parts of the world, for example the USA and Spain, a water market provided the best means of distributing limited and erratic water supplies. This holds true especially for agricultural use, where the market procedure tends to result in the most equal distribution of losses associated with drought.

4 INTEGRATED WATER MANAGEMENT

It is out of the scope of this abstract to discuss the importance of integrated water management. This urgent need therefore has been felt largely by the authors of policy plans over the last decade. The question is to what extend they were successful with the real implementation measures both in the Netherlands and abroad.

The issues concerned:

- it is felt that policy development and implementation of measures in water management are out of balance. At the regional level water managers are confronted with complex problems not only related to water issues, but also involving physical and environmental planning
- setting priorities of water use is the greatest responsibility of water authorities. They need adequate tools for the weighing and ranking of interests, partially based on opportunity costs of water and partially on policy decisions
- an integrated approach has been promoted by decision-makers to make possible rational water use decisions
- an essential part of water policy plans concerns land use, which determines to a large extent the water demand. The quality of the environment and the environmental potential largely depends on the user functions addressed to an area
- allocation of investments in the water or related sectors in defined areas should be aimed at maximum economic and environmental benefit. It means that sustainability is a prerequisite for all measures to be taken.

The Netherlands Governmental Institute for Inland Water Management and Waste Water Treatment (RIZA) is a technical-scientific organisation, part of the Directorate-General for Public Works and Water Management (RWS) and belonging to the Ministry of Transport, Public Works and Water Management. Currently, RIZA employs about 400 people and this number from January 1996 onwards will increase to circa 470.

The institute works in a multi-disciplinary way and has expertise on the biological, physical and chemical processes that take place in water and sediments, in groundwater and on techniques for treatment of wastewater.

The institute advises national government and a.o. waterboards on the granting of permits for the discharge of wastewater, on the development of cleaner production processes in the industry but also on the hydrological and morphological consequences of, for example, the construction of a storm-surge barrier, on the ecological rehabilitation of rivers and on the optimization of monitoring techniques. RIZA is also involved in matters concerning the groundwater problems of The Netherlands and gives advice on discharges and emissions into the sea. The institute plays an important role in the development of Netherlands government policy regarding watermanagement.
In order to give solid, well founded advice, it is necessary to do research and gather data; RIZA partly carries out these tasks by herself, part is contracted to other institutions, universities, etc.

RIZA's primary concern are the Netherlands inland, fresh waters. The institute however has many international contacts. This is a result of the situation of The Netherlands in the delta of three major international rivers: the Rhine, the Meuse and the Scheldt. Problems concerning the Netherlands rivers can only be dealt with effectively in collaboration with the other countries in the catchment areas. This applies also to the North Sea.

Furthermore, water policy is increasingly being developed within an international context. This is the case for the management of the Rhine, the Meuse and the Scheldt. The European Union is very important in this respect but other organisations are active in the environmental field as well. RIZA staff members frequently represent The Netherlands in international consultations.

The Netherlands is also involved in environmental projects within the context of the development of the Third World and Eastern Europe. RIZA contributes in these projects too, sometimes via memoranda of understanding, mutual agreements about certain fields of cooperation between Netherlands and foreign ministries.

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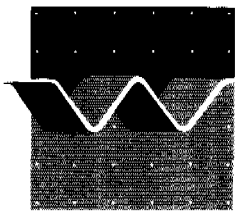

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TNO Institute of Applied Geoscience

Institute
TNO Institute of Applied Geoscience is part of the Netherlands Organization for Applied Scientific Research, TNO (staff 4000). The institute is the central institute for groundwater research and the management of groundwater information in the Netherlands and the largest independent institute for geo-energy research in the country.

Mission
Through research on geoscience and related technological research the institute contributes to the sustainable management and use of the subsurface and subsurface natural resources.

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- Geo-energy:
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Type of Expertise
- Groundwater:
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  - Water resources management
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    - Water development planning
    - Water use policy development
  - Information technology
    - Groundwater information systems
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  - Institutional support to ministries and national oil companies (establishment of knowledge/ data/tool/infrastructure)

TNO Institute of Applied Geoscience has worked internationally since its inception in 1967. The institute has long standing experience in institution building and the transfer of know-how in developing countries.

TNO Institute of Applied Geoscience is member of GEONETH, a network of Netherlands geoscience institutes, universities, foundations and government agencies for international cooperation.

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