Working paper
Facts and Figures Kenya, Iran and the Netherlands

WatManSup project



Kenya:
SASOL Foundation
University of Nairobi

Iran:
Agricultural Engineering Research Institute
Isfahan Agricultural and Natural Resources Centre

PARTNERS VOOR WATER
Bundeling van krachten

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Waterschap Hunze en Aa's

FutureWater Science for Solutions

Working paper
Facts and Figures Kenya, Iran and the Netherlands

WatManSup project

[CONCEPT VERSION]

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ADOPTED FROM EXISTING DOCUMENTS

Contents

1 Introduction

This report is the first working paper of the Project WatManSup. The full name of the project is "Integrated Water Management Support Methodologies: a case study in Iran, Kenya and the Netherlands".

1.1 Background

The challenge to manage our water resources in a sustainable and appropriate manner is growing. Water related disasters are not accepted anymore and societies expect more and more that water is always available at the right moment and at the desired quantity and quality. Current water management practices are still focused on reacting to events occurred in the past: the re-active approach. At many international high level ministerial and scientific meetings a call for more strategic oriented water management, the pro-active approach, has been advocated. Despite these calls such a pro-active approach is hardly adopted by water managers and policy makers.

Water managers and decisions makers are aware about the necessity of this paradigm shift: from a re-active towards a pro-active approach, but are confronted with the lack of appropriate methodologies.

To be prepared for the paradigm shift Integrated Water Management Support Methodologies (IWMSM) are needed that go beyond the traditional operational support tools. Note that these IWMSM are more than only tools, but include conceptual issues, theories, combining technical and socio-economic aspects. The objectives of the Project WatManSup are to combine different water management tools and test these tools for two case study areas in Kenia and Iran.

The project is implemented by the Institute for Environmental Studies of the Free University Amsterdam, one of the Dutch water boards Hunze en Aa's and the Dutch research company FutureWater. The project is financially supported by Partners for Water as a joint initiative of six departments of the Government of the Netherlands.

1.2 Working paper No.1

This working paper contains facts and figures about the three countries involved in the WatManSup project. It is composed of parts of existing documents and is only intended for internal use. In chapter 2 to 4 the case study areas in Kenya, Iran and the Netherlands are treated subsequently. The last chapter gives an overview of the references used in this document.

2 Kenya

2.1 Regional setting

The Kitui District in the Easter Province is a semi-arid region situated 150 km eastern of Nairobi (Figure 1). The total land area is approximately 20.000 km² including 6.400 km² of the uninhabited Tsavo National Park. The elevation of the district is between 400 and 1800 metres. The central part of the district is characterised by hilly ridges, separated by low lying areas between 600 and 900 metres above sea level. Approximately 555.000 people inhabit the district and the growth rate is 2.2 percent a year (DDP,2002).

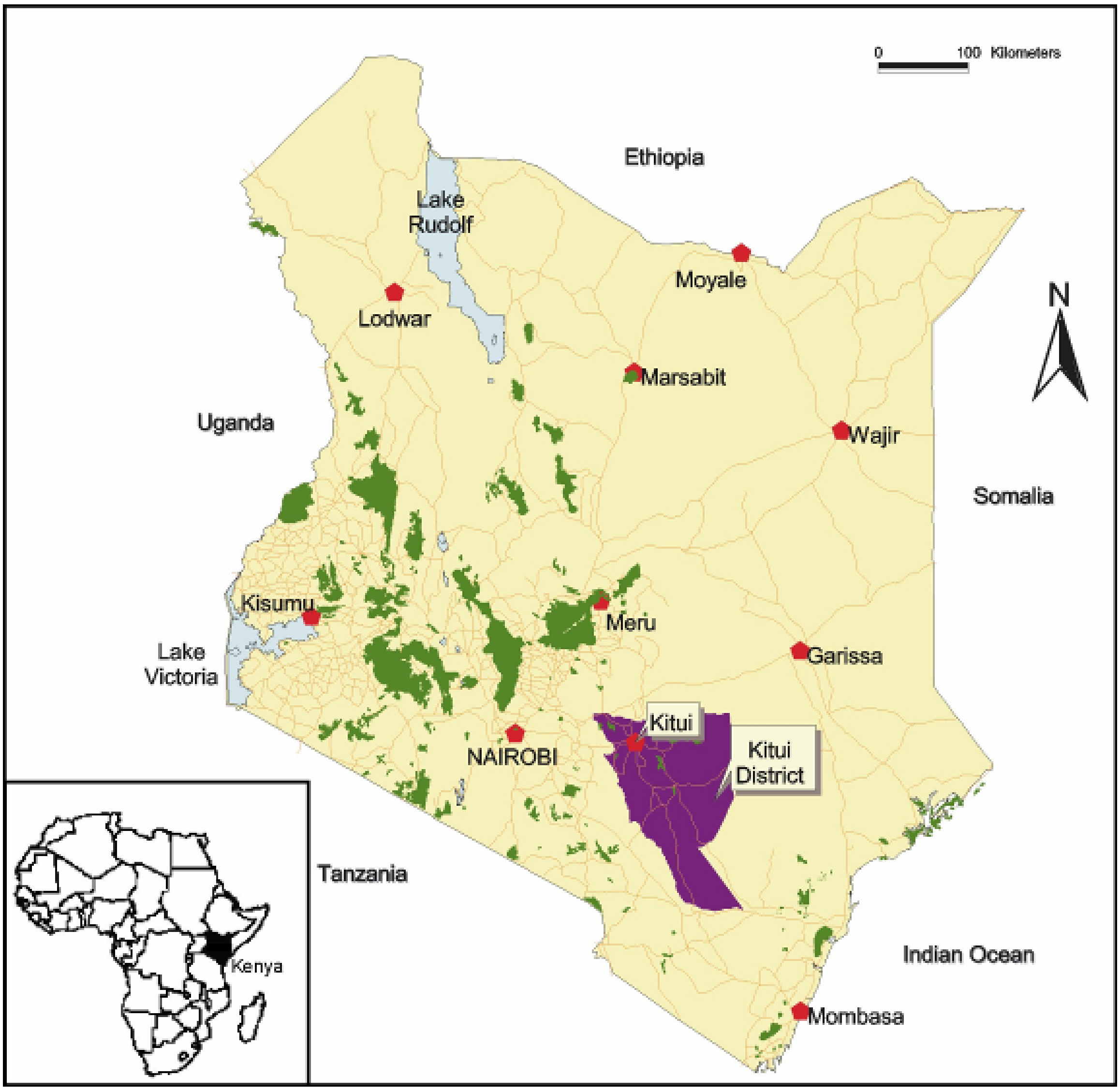

Figure 2.1: Map of Kenya, with the Kitui district in dark.

2.2 Geography and climate

The area is characterised by rainy periods that are highly erratic and unreliable. It usually falls in a few intensive storms (Nissen-Petersen, 1982). There are two rainy seasons, one from April to June, these are the so-called 'long rains' and one from October to December, these are the 'short rains'. On average the precipitation in the Kitui District is around 900 mm a year, but there are large local differences in amount of precipitation due to topography and other influences. The potential evaporation is high, 1800 to 2000 millimetre a year.

2.3 Socio-economical data

In 1997 the income of 58 percent of the eastern districts was beneath the poverty line of 2 dollars a day (PRSP, 2001). This is one of the poorest regions of Kenya. The main economic activity is rainfed agriculture (Census,1999). Irrigated agriculture only takes place on small plots on the river banks. During prolonged dry periods the farmers are dependent on relief food from donors. In 2004 and spring 2005 up to 50 percent of the inhabitants of Kitui received food aid (FEWS-NET). Besides farming the main economic activities are charcoal burning, brick making and basket breading.
Only 45 percent of Kenyans have access to clean water for domestic use and even fewer have access to water that is fit to drink. In the Kitui district these numbers are even lower only 6 percent of the inhabitants has access to potable water (DDP, 2002). Water is the most essential development commodity in this area, the major sources are the ephemeral rivers. Water scarcity forces women and girls to walk up 20 kilometres in dry periods to water sources such as springs and scoop holes.

2.4 Water management and institutional aspects

The institutional framework surrounding the sand dam project comprises several actors on various institutional levels. By means of interviews with representatives, information was gathered concerning i.e. the responsibilities, the level of cooperation and the coordination structure of the different actors. The results are presented according to the three institutional levels: NGO level, community level and government level.
In the bottom-up approach practiced by SASOL, community participation plays an important role. The organization only facilitates construction materials, knowledge and the required funding, keeping the total costs as low as possible. The 8-step methodology includes formal meetings, selection of the site and site-confirmation by SASOL. At the end of the pre-constructive phase, the community selects a dam committee who is responsible for the organization of the site and for the long-term utilization of the dam. During construction and in the post-constructive phase several trainings are given. These sub-locational training sessions cover subjects like project management, natural resource management and catchment development. In some cases, Ex-change (a Dutch NGO) cooperates with SASOL, by providing student teams to help the community with the construction of the sand dam.

At community level, the village elder and the newly formed dam committee fulfil the most important roles. Being the official spokesperson for the community, the village elder is approached first by SASOL to discuss the Sand Dam Project and its impacts. The responsibilities of the village elder are overall supervision of the site, the participants and the materials and the protection and utilization of the dam. The dam committee has very similar responsibilities, including supervision of the site, organizing the community, and managing and maintaining the sand dam. In cooperation with SASOL, the committee also sets up rules and regulations for the construction period and for utilization and maintenance of the sand dam after construction.

The highest institutional level is the Kenyan government. The various levels of government (ranging from national to district) are not only regulatory institutions, but are also active in setting up projects in sectors as agriculture, irrigation and health. This is mostly done through extension officers who visit communities and give advice on various topics. For this reason, the ministries could play a major factor in making the Sand Dam Project a success. The Ministry of Water and Irrigation is responsible for the development of water resources, and therefore closely connected to SASOL. Although the Ministry is aware of SASOL's activities, there is little cooperation between the two parties; making the outcome of the project less effective due to insufficient support and follow-up services from the Ministry.
The Water Act 2002 is a new policy concerning the management of the water resources. The act supports a minimal role of the government and greater community participation. In the near future, water user groups may become an important entity on district level and it is recommendable that these groups work together with the dam committees.
Another important actor is the District Development Committee. Since 2002 the Kitui Sand Dam Project is incorporated into the Districts Development Plan (DDP for 2002-2008). Because of an increased awareness of SASOL's activities at the government, it is expected that extension services to sand dam-communities will be better matched to their situation (proper utilization of the resources).

3 Islamic Republic of Iran, Zayandeh Rud River Basin

3.1 *Regional setting*

Iran, or Persia, as it was known until 1935, is located in South West Asia. The 1,648,000 sq km large country is bounded by Turkmenistan and the Caspian Sea, Afghanistan, Pakistan, the Persian Gulf, the Gulf of Oman, Iraq and Turkey, see figure 1. Iran's vast terrain consists of barren desert in the east and center, and mountainous regions in the north and west. Iran, with two of the world's most arid deserts, Dasht-e-Kavir and Dasht-e-Lut, is one of the most arid regions of the world, and suffers frequent droughts, floods and landslides. In addition, due to its position in the Alpine-Himalayan mountain system, Iran is also subject to numerous and often severe earthquakes (UNDP).
The Zayandeh Rud is the most important river in Esfahan Province in central Iran. Largely fed by snowmelt from the Zagros Mountains it flows down into the basin which contains the city of Esfahan (Figure 1). It is a closed basin with no outflow to the sea; the river terminates in the Gavkhuni Swamp which is a natural salt pan (Salemi et al., 2000).

Figure 1: Location of Zayandeh Rud basin, Iran (Unicef, Salemi et al., 2000)

The river has provided the basis for centuries of important economic activity, including the growth and establishment of Esfahan itself as the former capital city of Persia. The region has been able to support a long tradition of irrigated agriculture as well meet the domestic needs for a substantial population. More recently large increases in industrial activity have increased demand for water, and the Zayandeh Rud is showing typical signs of a river basin under threat (Salemi et al., 2000).

The Zayandeh Rud basin covers 41,500 km2, with the main Zayandeh Rud running for some 350 km roughly west-east from the Zagros Mountains to the Gavkhuni Swamp. The basin is closed, with no outlet to the sea (Figure 2). The Zagros Mountains, which form the natural divide between the inland basins of Iran and the Persian Gulf, are the natural watershed for much of Iran. Steep and rugged, and rising to 4548 m, they are of little importance agriculturally and have not formed the basis for large settlements (Salemi et al., 2000).

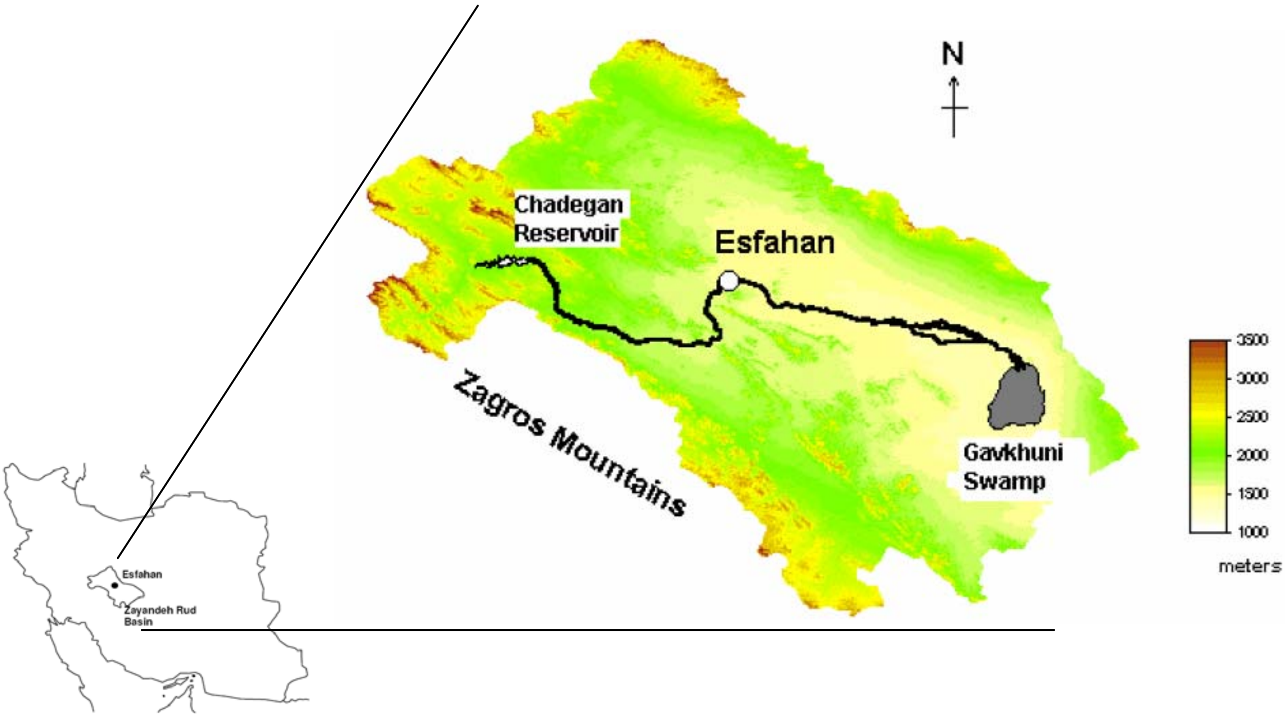

Figure 2: Elevation in Zayandeh Rud River Basin (Salemi et al., 2000)

The Chadegan reservoir provides storage of winter and spring runoff and its releases are used to regulate flows in the river. There is a series of diversion weirs along the river, and numerous locations where urban areas and industry can extract water. The **upper catchment** covers about 4,000 km2 or less than 10% of the total catchment. The upper catchment is mountainous, with peaks rising to as much as 3,500 meters, and there is little utilization of water upstream of the reservoir. There are natural forests in the upper catchment although most of the higher land is barren (Murray-Rust et al., 2000).
The **central and lower portions of the valley** are natural arid and sub-arid areas. Steep mountain ranges rise up out of the valley floor, but the majority of the landscape consists of gently sloping alluvial fans with dry streambeds where there are occasional flash floods in rare storms. The natural vegetation here is sparse thorn bush and drought resistant grasses, and there is a high percentage of bare rock and soil (Murray-Rust et al., 2000).
The basin terminates in the Gavkhuni Swamp which is a natural salt pan. Much of the area surrounding the swamp is sandy and there are extensive dune areas just east of the swamp. Water entering the swamp area is extremely saline, with EC values as high as 30 dS m-1 during periods of low flow (Salemi et al., 2000).

3.2 *Climate*

The basin has a predominantly arid or semi-arid desert climate. Rainfall in Esfahan (Figure 3), which is situated at an elevation of 1800 m, averages only 130 mm per year, most of the rainfall occurring in the winter months from December to April. During the summer there is no effective rainfall. Temperatures are hot in summer, reaching an average of 30^{o}C in July, but are cool in winter dropping to an average minimum temperature of 3^{o}C in January. Annual potential evapotranspiration is 1500 mm, and it is almost impossible to have any economic form of agriculture without reliable irrigation (Salemi et al., 2000).

The climatic conditions in the mountains are markedly different, as shown by data from Kuhrang which lies just to the west of the Zayandeh Rud catchment (Figure 3). Situated at an elevation of almost 2300 m, precipitation averages 1500 mm, much of it in the form of snow, and snow remains on the ground throughout the winter, only melting when temperatures warm up from April onwards. Winter temperatures are normally below freezing for weeks at a time, although summers are pleasant with average maximum temperatures of 22^{o}C in July (Salemi et al., 2000).

Most runoff originates from the mountains surrounding the basin, particular in the Zagros range, and most of this runoff is in the form of snowmelt rather than direct runoff from precipitation. This is illustrated by data from Kuhrang meteorological station (elevation 2285 m), located to the west of the Zayandeh Rud basin, presented in Table 1. More than 89% of the precipitation occurs between November and March, with an annual average of 70 days of precipitation. Of these 70 days about 55 experience snowfall rather than rainfall, and with cold winter temperatures that may not rise above freezing for weeks at a time, most precipitation remains in the form of ice and snow until temperatures rise in April (Murray-Rust et al., 2000).
The effect of spring snowmelt is that peak discharges are experienced during the time of year when agricultural demand for water is also rising. This has enabled irrigation to become an important economic activity for some centuries, and was the basis for the historical importance of Esfahan several hundred years ago (Murray-Rust et al., 2000).

Table 1: Average climatic conditions, Kuhrang (elevation 2285 meters) 1987-1996 (Murray-Rust, 2000)

	Air Temperature (oC)			Precipitation		
Month	Ave. Max.	Ave. Min.	Ave. Daily	Monthly Total	Wet Days	Days with Snow
October	18.5	4.5	11.5	47.3	5.6	0.1
November	11.9	0.1	6.0	191.2	8.6	3.6
December	4.9	-6.5	-0.8	249.5	12.0	10.4
January	0.5	-11.5	-5.5	204.6	12.9	12.4
February	2.6	-8.9	-3.1	250.3	13.2	12.6
March	5.6	-4.3	0.6	344.3	15.8	13.0
April	12.1	1.7	6.9	147.6	11.5	2.0
May	19.8	7.3	13.5	52.2	7.3	0.1
June	26.3	10.7	18.5	0.9	1.0	0.0
July	29.9	14.2	22.1	1.0	1.0	0.0
August	29.8	13.8	21.8	1.2	0.7	0.0
September	25.7	9.5	17.6	1.8	0.9	0.0
Year	15.6	2.5	9.1	1492.0	70.5	54.2

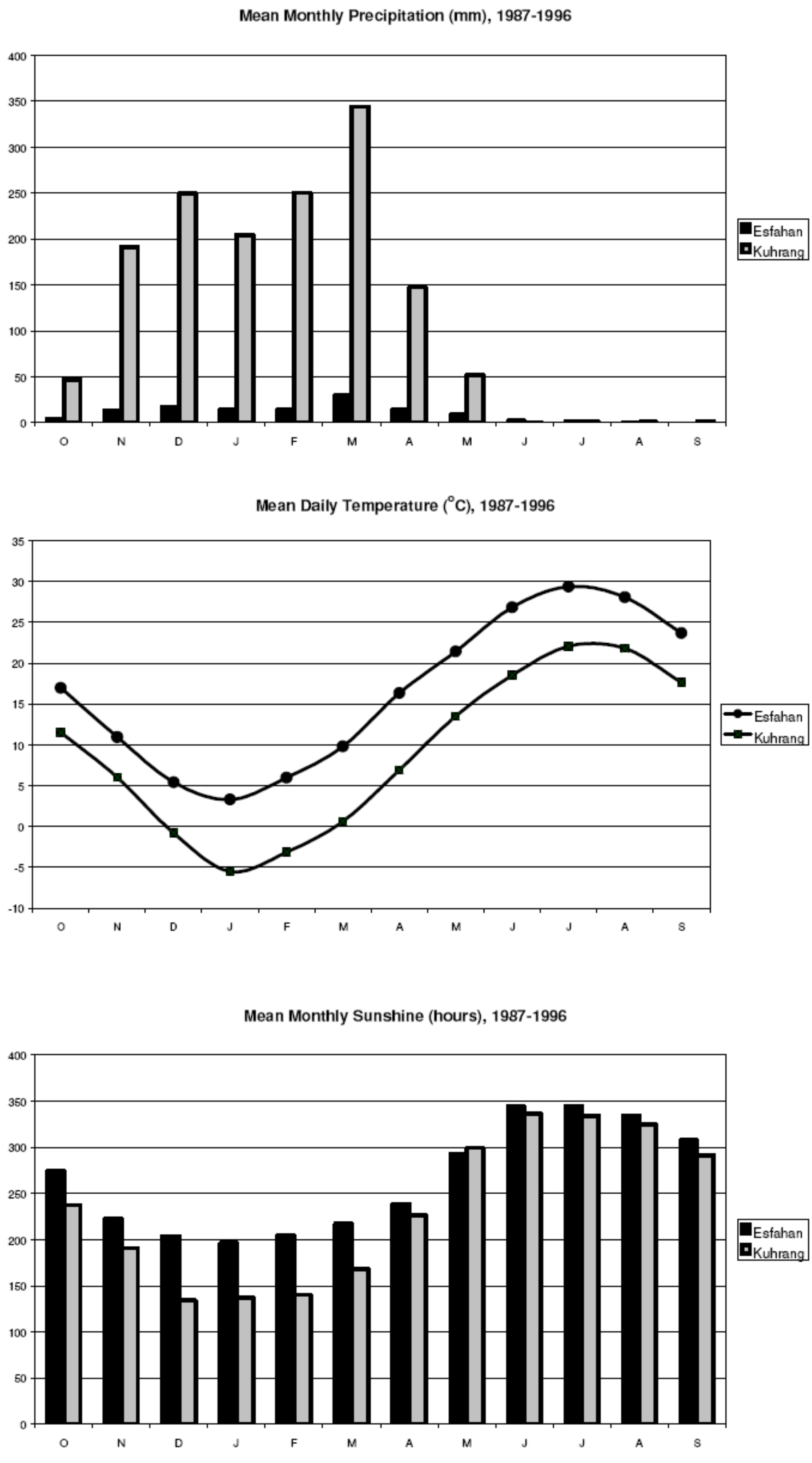

Figure 3: Comparison of climatic data: Esfahan and Kuhrang (Salemi et al., 2000)

3.3 Hydrology

3.3.1 Water supply

The area of the Zayandeh Rud basin is some 41,500 km^2. However, only the area upstream of the Chadegan reservoir makes any significant contribution to the stream flow. The total water supply in the basin is augmented by the diversion of water from the Kuhrang River into the upper reaches of the Zayandeh Rud. Two diversion tunnels in operation since 1986 can deliver 540 million cubic meters of water a year while a third tunnel, expected to be ready in a few years, will deliver a further 250 million cubic meters of water annually. Inflow and release in the Chandegan reservoir show a consistent annual pattern (Murray-Rust et al., 2000).

The main period of runoff is from March to July when there is more than 150 million cubic meters of inflow into the reservoir in each month, peaking in April and May when average inflows exceed 300 million cubic meters (over 115 m3/sec). In contrast, winter discharges are very low even though this is the period of maximum precipitation in the catchment and from August to February, inflows average less than 100 million cubic meters. Total average inflow is approximately 1700 million cubic meters per year, see also Annex 1 (Murray-Rust et al., 2000).

Besides the river supply the local people also use the groundwater in a large scale. On basin level the total ground water use is estimated on 3500 MCM per year (compared to 1500 MCM/yr water release from Chandegan Dam). The bulk of this water is used for agricultural production. In the irrigation districts near the Zayandeh Rud river the groundwater use is high because aquifers are shallow (10-50m) and groundwater is easy accessible (Hoogesteger van Dijk, 2005).

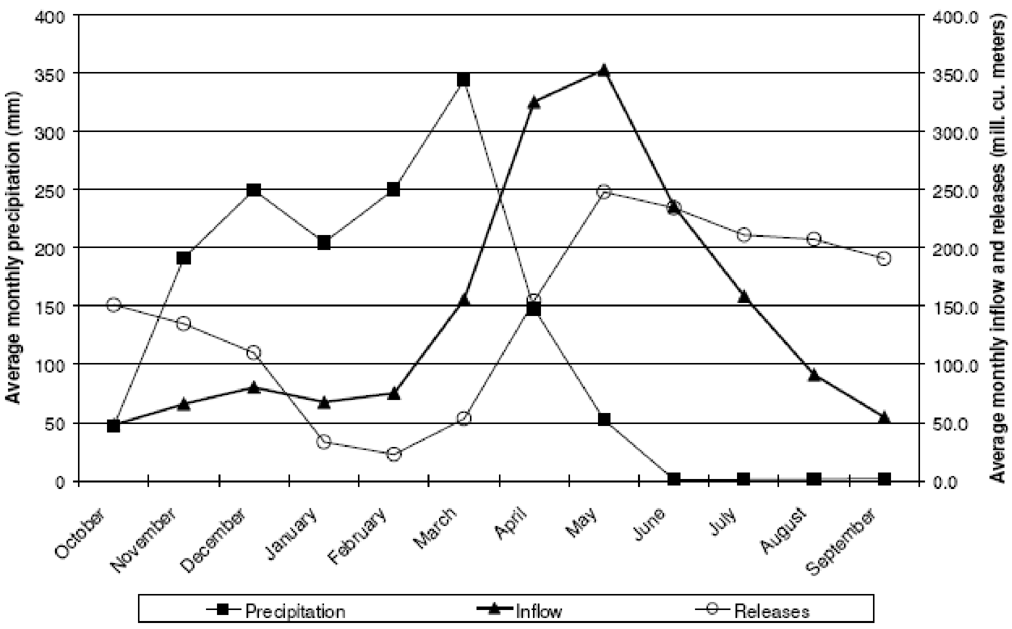

Figure 4: Average monthly inflow, release and precipitation in Chandegan reservoir (Murray-Rust et al., 2000)

3.3.2 Water demand

With annual potential evapotranspiration in the order of 1500 mm, it is almost impossible to practice any reliable agriculture in the Zayendeh Rud basin without irrigation. It has only been in the past few decades that irrigation has been developed in the form of large-scale, integrated systems with proper devices for conveyance, distribution and measurement of irrigation flows. The location of the main irrigation systems and the diversion weirs serving them are shown in Figure 5, while the main data on the irrigation systems are presented in Table 2.

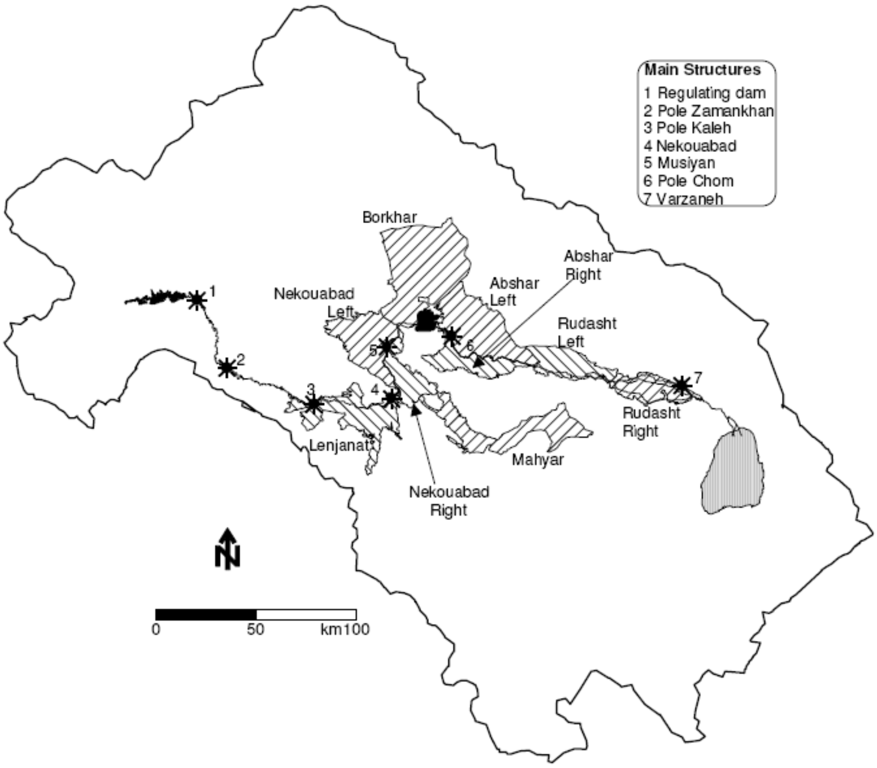

Figure 5: Main irrigation systems and regulating structures in the Zayandeh Rud basin (Murray-Rust et al., 2000)

Table 2: Main features of the irrigation systems in Zayandeh Rud basin (Murray-Rust et al., 2000)

Name of System	Date of Construction	Designed Command Area (ha)	Design Discharge (m^3/sec)	Length of Main Canal (km)	Length of Secondary Canals (km)
a) Old Systems					
Nekouabad Right Bank	1970	13,500	13	35.3	45.0
Nekouabad Left Bank	1970	48,000	45	59.4	76.6
Abshar Right Bank	1970	15,000	15	33.5	38.0
Abshar Left Bank	1970	15,000	15	36.0	33.0
b) New Systems					
Borkhar	1997	36,000	18	29.0	Not completed
Rudasht Left & Right	In Progress [(a)]	47,000	50	209.2	Not completed
Mahyar	In Progress	24,000	10	120.0	Not completed

Note: [(a)] Rudasht is an ancient system being replaced with a new system
All new systems have conjunctive use of surface water and groundwater

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3.4 Socio-economical background

3.4.1 Population

History of Iran goes back to the earliest days of civilization. It was in 550 B.C. that Persians and the Medes together made Iran. In the next thousand years Iran will be the most powerful country of the ancient world. This period of ancient civilization, which gave the country its language, came to an end with the Arab conquest and the Islam entered the country in the 7th century A.D (UNPD).

Islam is the official religion; about 90% of Iranians are Muslims of the Shiite sect. The remainder, mostly Kurds and Arabs, are Sunnis. Colonies of Zoroastrians at Yazd, Kerman, and other large towns. In addition to Armenian and Assyrian Christian sects, there are Jews, Protestants, and Roman Catholics. The principal language of the country is Persian (Farsi), which is written in Arabic script (UNDP). In addition to the local population, Iran has over the past two decades, hosted one of the largest refugee populations in the world. The estimated number of these refugees, mostly from war-torn Afghanistan and Iraq, has varied between two and four million (UNPD).

With an estimated population of 71.4 million, Iran (or Persia) is the most populous country in the middle-east region. The population growth is 1.1% in 2006 (CIA). In the Zayandeh Rud river basin the population grew from 1.1 million people in 1966 to 3.9 million in 1996. Esfahan populates about 2 million of the people. Another 900.000 people live in the other cities along the river and 1 million people are rural residents, living in the 1212 villages in the basin (Morid, 2004).

Iran continues to experience a transition from a traditional rural-based society to a semi-industrialized country and faces many challenges which include:
a) high unemployment (generally estimated to be above 25 per cent);
b) a distorted distribution of income and;
c) inequality of opportunity
Although poverty is officially set at 18 per cent of the population, 16.5 million people can be considered as living under the relative poverty line (Unicef).

Developments in education have been positive. In 2001 the literacy rate of the population aged over six years of age has reached 80.4 per cent (85.1 per cent of men and 75.6 per cent of women). The urban-rural gap has also narrowed to about 14 per cent (86.25 per cent of urban population versus 72.4 per cent of the rural). There are, however, still noticeable differences among and within Iranian provinces. The net enrolment ratio is above 97 per cent and is almost equal among girls and boys (Unicef).

3.4.2 Economy

With a Gross Domestic Product of US$110 billion, Iran is the second largest economy in the region. It is also the second largest Organization of the Petroleum Exporting Countries (OPEC) oil producer and has the world's second largest reserves of gas (Unicef). Besides crude and refined petroleum, Iran's chief exports are textiles, fruits, nuts, hides, and iron and steel. Its chief imports are machinery, metals, military supplies, food, and chemicals. Traditional handicrafts such as carpet weaving and the manufacture of ceramics, silk, and jewellery are also important to the economy.

About 10% of the land in Iran is arable; agriculture contributes just over 20% to the gross national product and employs a third of the labor force. The main food-producing areas are in the Caspian region and in the valleys of the northwest. Wheat, the most important crop, is grown mainly in the west and northwest; rice is the major crop in the Caspian region (UNDP).

3.5 *Water management and institutional aspects*

3.5.1 Esfahan Water Authority

Regulation of water resource exploitation and distribution is the responsibility of Esfahan Water Authority (EWA) that is supervised by the Ministry of Energy. This institute is responsible for surface and groundwater management in the basin. Within the irrigation sector the responsibility of the EWA extends to the outlet level. Water distribution in tertiary and lower level channel networks gets coordinated by the Esfahan Agriculture Authority under the supervision of the Ministry of Jihad and Agriculture (Morid, 2004).

3.5.2 Council for water distribution

Before the drought the EWA was responsible for taking decisions on water distribution to the different irrigation systems and for all the other uses determining how the dam was operated and how much water the different intakes were able to extract from the river. In 2000 however, because of the drought and the growing tensions about water distribution and use, a council was created to take decisions over water distribution. The council is formed by five members who are: a representative of the Regional Water Office (EWA) representing the Ministry of Energy; a representative of the Regional Irrigation Office of the Ministry of Jihad and Agriculture; a representative of the Mirhab[1]; a farmer representative and a representative of the provincial government.
This council meets on a monthly basis to decide how the water will be managed and distributed. Once the decisions have been taken in the council the EWA is responsible to carry these out. The creation of the council has helped the EWA to get a wider support by society now that it is supported by a council in which several sectors are represented. This shift has not developed without conflicts. For instance the environmental groups have been pushing hard to get water liberated for the environment while agriculturalists have created a great lobby for getting water freed for agriculture and the urban use keeps on expanding. There are even claims from cities outside of the Basin.
The EWA has vested a lot of hope in the construction of the third diversion tunnel and in better years of higher precipitation, yet it is conscious that in the near future a severe and sustained water scarcity can appear as usable good quality groundwater resources get reduced little by little, population keeps on increasing and ever more claims are made on the water resources (Hoogensteger van Dijk, 2005).

3.5.3 Water users

Agriculture remains the largest single user of water in the basin despite increased demands from other users of water. The data on extractions show that in a typical year as much as 90 % of water released from Chadegan reservoir is diverted into irrigation systems. Although there are also substantial return flows to the Zayandeh Rud they are of lower quality than the diverted water and may not be suitable for downstream users.

Esfahan is the second city of Iran with a population of some 2 million people. In recent years the Province has seen a significant industrial expansion with steel mills, refineries, cement works and a host of smaller industries established along the Zayandeh Rud. As in most other countries, industry is more able to pay for water than farmers, so there is a potential for decreased supplies for irrigated agriculture. Similarly, urban demand is rising annually not merely through population growth but also because more affluent people consume more water per capita.

Finally, and increasingly important, is the growing concern with environmental degradation, with pressure to maintain higher base flows to dilute pollutants so that acceptable water quality standards are maintained (Salemi et.al, 2000).

3.6 Annex

3.6.1 Annex 1

Table 3: Summary of monthly inflow data into Chandegan reservoir 1989-1998 (in million cubic meters)

Month	Average flow	Standard Deviation	Coefficient of Variation	Maximum	Minimum
October	47.9	16.6	0.35	89.4	26.2
November	65.9	31.8	0.48	120.0	33.7
December	80.2	55.6	0.69	235.9	38.0
January	67.3	24.4	0.36	106.5	37.0
February	75.2	26.5	0.35	119.1	37.3
March	155.8	82.0	0.53	310.4	52.4
April	325.6	95.1	0.29	466.8	183.2
May	353.2	107.3	0.30	572.8	224.9
June	235.6	62.3	0.27	368.3	140.6
July	158.6	58.6	0.37	285.0	79.2
August	91.2	43.3	0.47	198.2	39.1
September	54.6	27.3	0.50	127.1	29.1
Annual	1711.2	412.3	0.24	2504.9	1134.1

Table 4: Normal average monthly release from Chandegan reservoir

Average Monthly Releases (mill.cu.meters)			
Month	Average	Std. Dev.	Variance
Oct	143.7	40.9	28.5
Nov	122.3	43.9	35.9
Dec	103.8	57.4	55.3
Jan	31.4	15.9	50.8
Feb	19.1	4.0	21.0
Mar	44.3	25.1	56.6
Apr	130.5	23.5	18.0
May	206.6	17.7	8.6
Jun	217.6	12.5	5.7
Jul	203.5	18.1	8.9
Aug	201.5	19.8	9.8
Sep	179.0	16.0	8.9
Annual	1579.0	215.1	13.6

3.6.2 Annex 2

Table 5: Cropping pattern in major irrigation systems in Zayandeh Rud basin

Crop	Crop Calendar		Nekouabad		Abshar		Rudasht		Borkhar		Mahyar	
	Planting Date	Harvest Date	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent
a) Winter												
Wheat	Nov	Jun	21832	35.5	14587	43.5	18062	38.4	13000	36.1	1528	17.0
Barley	Nov	May	4982	8.1	1857	5.5	3539	7.5	4000	11.1	719	8.0
Onion	Oct	Jun	8118	13.2	1061	3.2	0	0.0	0	0.0	0	0.0
Fodder	Oct	Jun	4920	8.0	1226	3.7	0	0.0	0	0.0	0	0.0
b) Summer												
Rice	Jun	Oct	15006	24.4	0	0.0	0	0.0	0	0.0	0	0.0
Potatoes	Feb	Jun	5744	9.3	0	0.0	0	0.0	0	0.0	0	0.0
Vegetables	Mar	Oct	12054	19.6	4100	12.2	0	0.0	2150	6.0	0	0.0
Corn	Jun	Oct	0	0.0	973	2.9	839	1.8	1450	4.0	450	5.0
Cotton	May	Nov	0	0.0	0	0.0	2228	4.7	150	0.4	0	0.0
Melon	May	Jul	0	0.0	0	0.0	1970	4.2	0	0.0	0	0.0
Sunflowers	Apr	Sep	0	0.0	0	0.0	0	0.0	1700	4.7	0	0.0
Millet	Jul	Oct	0	0.0	0	0.0	0	0.0	0	0.0	2246	25.0
c) All year												
Sugarbeet	All year		1599	2.6	2416	7.2	7241	15.4	2600	7.2	1078	12.0
Orchards	All year		6863	11.2		0.0	0	0.0	0	0.0	0	0.0
Alfalfa	All year		7380	12.0	3189	9.5	1677	3.6	1600	4.4	450	5.0
Grapes	All year		0	0.0	0	0.0	0	0.0	0	0.0	719	8.0
Actually Cropped Area (ha)			88498		29409		35556		26650		6471	
Canal command Area (ha)			61500		33554*		47000		36000		8987	
Annual Cropping Intensity			*143.9%[a]*	169.7	*87.6%[a]*	104.4	*75.7%[a]*	94.6	*74.1%[a]*	85.7	*72.0%[a]*	105.0
Winter Cropping Intensity				90.6		72.5		64.9		58.9		50.0
Summer Cropping intensity				79.1		31.8		29.7		26.8		55.0

** includes area irrigated by tubewells as well as the surface irrigation system*

[a] Ratio of actual cropped area to canal command area

Source: Ministry of Agriculture, Esfahan Province

4 Netherlands

4.1 Regional setting

2 Geography

This chapter deals with the situation of the Netherlands in north-west Europe. It pays attention to the geological structure and the soils. Land use is also an important issue in this geographical description.

2.1 Situation and elevation

The Netherlands, having a land area of approximately 34 000 km^2, is situated along the North Sea in north-west Europe (Figure 2.1). The total territory, including inland lakes, estuaries and territorial sea, amounts to 41 160 km^2. The Netherlands comprises the deltas and former flood plains of the rivers Rhine, Meuse and Scheldt (Figure 2.2).

The western and northern parts have an elevation varying between slightly above and about 6 m below mean sea level (m.s.l.) and have little relief except for the coastal dunes. The lowest point, east of Rotterdam, is 6.7 m below m.s.l. About 25% of the land area lies below m.s.l. In the absence of dunes and dikes more than 65% of the country would be flooded at high sea and high river levels (Figure 2.3). In general the Netherlands slope from south-east to north-west. The highest point (322 m above m.s.l.) is found in the hilly region of the south-east where the national boundaries of the Netherlands, Belgium and the Federal Republic of Germany meet. The central part of the country north of Arnhem is slightly hilly with a maximum altitude just over 100 m above m.s.l.

2.2 Geology and soils

Throughout much of the country Tertiary and Mesozoic deposits are situated at great depth. The only outcrops occur at shallow depths in the south-eastern and eastern areas. The marine clay layers of Tertiary age are found at a depth of about 400 m and act as an impermeable base to the groundwater aquifer system. Nearly everywhere the Tertiary and Mesozoic formations are covered by Pleistocene and Holocene deposits. This is illustrated in Chapter 3 (Figure 3.6), where a geological profile is presented.

Figure 2.1 The Netherlands, part of Europe

Figure 2.2 Catchment areas of the rivers Rhine, Meuse and Scheldt

The greenhouse area, located between Rotterdam and The Hague, is quite famous and produces a wide range of vegetables and flowers. The Aalsmeer region, south of Amsterdam, is famous for its flowers. Fruit-growing is concentrated in the south-west, the south-east and in the areas between the large rivers and the new polders around Lake IJssel.

Demography

The population of the Netherlands amounts to 15.7 million (1997) against a mere 5.1 million at the turn of the century. Over the past decade the annual natural increase averaged 4 per 1 000. The present population density has an average of 460 people per km^2. Fifty percent of the people live in the very densely populated western part of the country, the so-called Randstad. In January 1997 the total working population amounted to 6.8 million of which 6% were unemployed. The number of people working in the various sectors of the economy has changed drastically since 1900. In that year 31% worked in the agricultural sector, 34% in industry and 36% in the trade and service sectors. In 1993 the figures were 4%, 25% and 71% respectively.

The national income of the Netherlands amounted in 1997 to more than NLG 717 160 million (NLG = Netherlands Guilders). The distribution of this amount among the various sectors is given in the Table. The national income per capita amounts to NLG 46 000.

The economy of the Netherlands has a long standing and pronounced international orientation. For centuries the interest has lain in foreign trade and the transfer of knowledge to industry. It has to be stated that the discovery and exploitation of natural gas are particularly important for the Dutch economy. Until 1970 the trade balance was negative. However, this was transformed by the large export of natural gas from 1970 onwards. In 1997 the total value of imported goods amounted to NLG 295 980 million, whereas the value of exported products amounted to NLG 321 420 million. This resulted in a surplus of NLG 25 440 million.

The breakdown of the national income (market prices) over the various sectors in 1997 (National Bureau of Statistics)

	sector	in NLG x10^9	%
1	agriculture, forestry, fishing	20.0	2.8
2	mining and quaring, manufacturing	156.6	21.8
3	construction	35.5	5.0
4	trade, tourism	96.0	13.4
5	transport, communication	47.9	6.7
6	government, defence, education	65.5	9.1
7	service sector	252.2	35.2
8	taxes	62.9	8.8
9	interest	-27.7	-3.9
10	foreign income	8.2	1.1
	national income	717.1	100.0

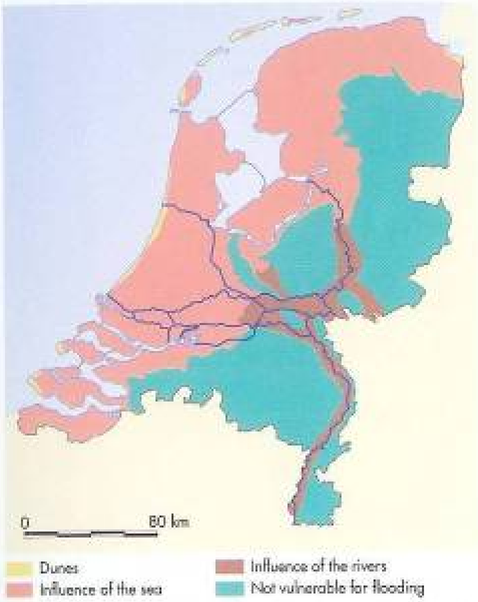

Figure 2.3 *The vulnerability of the Netherlands for flooding*

At the surface in the south-western, western, northern and central river districts, mainly loamy and clayey material of marine and fluviatile origin dominates, together with some peat soils (partly covered with marine and fluviatile sediments) and fine sands (see also Figure 3.3). In time the drawdown of the groundwater table by drainage works has caused shrinkage and oxidation of the clay-peat soil by several metres in the western, northern and river areas. This makes the Netherlands vulnerable to storm surges and river floods. The soils in the eastern and southern parts of the Netherlands mainly consist of fine loamy sand (cover sand), medium and coarse sand (often gravel). In the south, silt and silt loam (loess) occur.

2.3 Land use

As shown in Table 2.1 more than 70% of the total land area consist of cultivated land, of which almost two thirds are pastures and the remainder is used as arable land and for horticulture. Since 1950 the area of cultivated land has decreased. Woodland and uncultivated land together account for no more than 13% and urban and industrial areas for almost 17% of the total land area. Arable farming is mainly found on the fertile, well-drained marine clay soils in the north and south-western parts of the country and in the recently reclaimed polders. The most important crops are cereals, potatoes, sugar beet and corn. Livestock farming is usually located on clay and peat soils where dairy farming predominates. Mixed farming is traditionally practised on the sandy soils in the east and south of the Netherlands. Many of these farms specialize in pig and poultry farming (factory farming).

Table 2.1 *Land use in the Netherlands in 1994 (Central Bureau of Statistics)*

	land area (km^2)	%
Cultivated land	23 833	70.2
Woodland	3 041	9.0
Uncultivated land (heath, dunes, etc)	1 438	4.3
Built-up areas (incl. roads, etc)	5 595	16.5
Total land area	33 907	100.0

Horticulture is practised in many areas. Most well-known are the bulb fields behind the dunes around Leiden and Haarlem, although nowadays bulbs are grown in many other regions too.

4.2 *Climate and hydrolohy*

3 Climate and hydrology

This chapter gives the characteristics of the climate, surface water and groundwater in the Netherlands. The transboundary rivers Rhine and Meuse play an important role in the hydrology of this country.

3.1 General characteristics

The Netherlands is located in the temperate zone, but due to strong maritime influences its climate is much milder than average conditions at the 52°N latitude. The annual average temperature in the centre of the country is between 9 and 10 °C, while the annual average temperature at the 52°N latitude is close to 4 °C. Apart from this large scale maritime, or rather oceanic effect, there is also a small scale effect caused by bordering the North Sea. This results in marked gradients in most climatological characteristics within the first tens of kilometres from the coast. In a sense the climate of this transition area may be called the coastal climate, as distinct from the inland climate, where gradients are generally small. In Table 3.1 some climatological characteristics of the coastal and inland climate of the Netherlands are compared. Data are based on observations during the years 1961-1990.

Table 3.1 Some climatological characteristics for the meteorological stations De Kooy and Twente Airbase, based on observations for the period 1961 to 1990

	De Kooy (coastal station)	Twente Airbase (inland station)
Mean temperature (°C)		
January	2.7	1.5
July	16.2	16.4
Mean daily temperature amplitude (°C)		
January	4.2	4.9
July	5.9	9.9
Mean relative humidity (%)		
January	88	90
July	81	79
Mean annual duration of sunshine (hr)	1 581	1 377
Mean annual wind speed at 10 m over flat open terrain (m/s)	7	4
Mean precipitation (mm)		
annual	757	769
driest month	40	46
wettest month	91	76

As expected the coastal area is milder in winter and cooler in summer, in comparison to the inland area. This means that the yearly amplitude of temperature in the coastal areas is smaller than in the inland area. The same applies to the daily temperature amplitude. The differences between the coastal and inland

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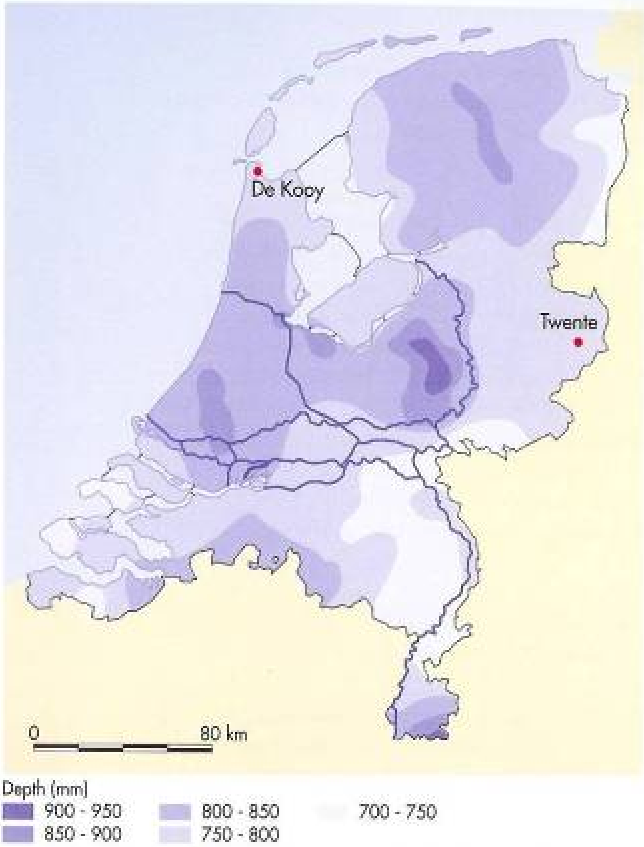

Figure 3.1 *Mean annual precipitation in the Netherlands*

climate are most pronounced in wind velocity and duration of sunshine. The more sunny climate of the coastal areas is of course attractive, but as one can see in Table 3.1, it is only at the cost of a much higher wind speed. Relative humidity is nearly the same in both areas.

3.2 Precipitation

According to the data given in Table 3.1, the coastal climate is drier on an annual basis, than the inland climate. However, such a conclusion is not generally valid. First of all, precipitation amounts are highly variable, even at time scales of 30 years. This means that a difference of some tens of millimetres in the annual mean amounts might well be oppositely directed in another 30-year period. In fact we have no indication of a systematic difference in precipitation amounts between the coastal and inland areas. As Figure 3.1 shows, the pattern of mean annual precipitation is somewhat more complex. Unfortunately, the figure is limited to the area within the borders of the Netherlands, which makes the delineation of certain features more difficult. In general the wettest areas coincide with the most hilly regions of the east-central and far south of the country. It may be concluded that these maxima are due to the orographic enhancement of precipitation. Other local maxima of precipitation are less easy to interpret. In some cases in the western part of the country, the large cities of Rotterdam and Amsterdam might be the cause. The areal average annual mean precipitation in the Netherlands is 750 mm and nowhere in the country do values deviate from this by more than 10-15%.

While the areal variation in precipitation amounts is small, the seasonal variation is more pronounced (Figure 3.2). Early spring is the driest season in all parts of the country. The wettest months are in the summer and late autumn, but again a clear distinction has to be made between the coast and the more inland part of the country. The heaviest showers occur in the inland in summer when surface warming is greatest. In the coastal areas the maximum is clearly shifted to the months October and November, due to showers developing over the relatively warm water of the North Sea.

As far as the temporal variation in precipitation is concerned the following characteristics may also be of importance. Interannual variability is quite large with the lowest annual amounts as low as about 400 mm and the highest nearly 1 200 mm. Daily and hourly amounts are usually mentioned according to their return periods. The 24-hour values that are exceeded on average once a year and once every 100 years are 34 and 73 mm, respectively. For hourly values and the same return periods these figures are 14 and 39 mm.

Finally it may be mentioned that about 70% of all precipitation in the Netherlands falls with wind directions between south and north-west. Some 10% falls in the form of snow.

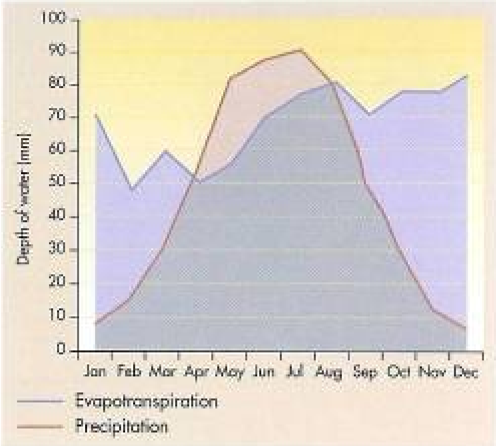

Figure 3.2 Mean monthly precipitation and the reference crop evapotranspiration

3.3 Evapotranspiration

Moisture conditions are not only determined by the amount of precipitation, but also by evaporation. Evaporation is governed by a number of meteorological factors, such as solar radiation, temperature, humidity and wind speed. The coastal areas with more solar radiation and higher wind speeds have higher evaporation rates than inland areas, even though in summer temperatures are usually lower. Evaporation is difficult to measure and estimates of actual evaporation are based on theoretical formulas concerning potential evaporation or rather evapotranspiration, since loss of water to the atmosphere is composed of evaporation of water surfaces or other wet surfaces and transpiration from vegetal covers (grass, arable crops, trees). According to the surface considered, evaporation or evapotranspiration may vary considerably. For example, open water in the Netherlands may evaporate as much as 700 mm per year, while annual losses from grass covered areas are several hundreds of mm less. Evapotranspiration from other crops is often smaller and paved surfaces have been found to evaporate only in the order of one or two hundred mm per year.

The mean annual evapotranspiration for the whole of the Netherlands is of the order of 550 mm, with values closer to 600 mm in coastal areas and 500 mm inland. As shown in Figure 3.2 the seasonal variation of evapotranspiration is very large, due to its dependence on solar radiation and temperature. The values in Figure 3.2 are based on the estimation of the so-called reference crop evapotranspiration E_r.

The seasonal cycles of precipitation and evapotranspiration give rise to a water surplus in winter and a moisture deficit in summer. At least this has been the case in most years. On average, in the period between October and March, a surplus of about 300 mm is built up; the maximum deficit which accumulates on average in the months April to September is of the order of 100-150 mm. In individual years conditions may be worse, however. In exceptionally dry years the maximum summer deficit may be as large as 300 mm.

3.4 Dry weather

The Netherlands is often called a rainy country, probably because of the large number of days with (some) rain. Indeed, everywhere in the country and in all months of the year the number of dry days is equal to or less than the number of days with rain. The average of 750 mm precipitation is small in comparison to the much larger amounts in mountainous areas or the tropics. Also the duration of rain at 6 to 7% of the time is certainly not significant. The point is that rainy days as well as dry ones usually occur in groups.

Statistically, at all stations in the Netherlands periods of 10 consecutive days of dry weather occur every year. Every 5-6 years dry periods of at least 3 weeks occur. Such periods of dry weather are convenient for all types of activities and only seldom cause a drought; these occur less than once in every ten years.

3.5 Natural variability and climate change

Apart from the effects of urbanization on climate other more large scale changes due to human activities are possible and are, in fact, expected. Here we refer to global warming as a result of the increasing greenhouse effect. We cannot exclude that the climate data for the period 1961-1990, used here, have already been affected by this process. On the other hand we will never be able to prove that such is the case, due to the natural variability of the climate. To give an example: when comparing the precipitation amounts at the De Bilt station in the centre of the country with comparable figures for the 30-year period 1931-1960 one can conclude that the climate has become wetter by nearly 40 mm. However, in view of the very large interannual variability of precipitation (standard deviation of about 150 mm) even 30-year averages in an unchanged climate are expected to vary considerably (standard deviation of nearly 30 mm). So a difference of 40 mm between 30-year averages is not unlikely and far too small to be considered as an indication of systematic climate change.

3.6 Landscape, soil and drainage

The general features of land and water in the Netherlands are characterized by the shaping of soil and landscape in geologically recent times. Sedimentation during the Pleistocene resulted in a vast and predominantly flat fluvial plain with mainly sandy soils, gently dipping to the north-west. Depending on the transport capacity of the subsurface, a stream pattern developed in the course of time, which is still draining the excess water in large parts of the southern and eastern regions. The presence of ice sheets during glacial periods strongly influenced the landscape of the northern half of the country. Deep valleys were scoured, either by melt water, or by the ice itself. Many of these valleys can be recognized in the present stream patterns. The sandy material removed by the ice was pushed into ridges; the low hills resulting are at present important groundwater recharge areas. Because of a coarse textured soil and deep groundwater levels, these hills are less suited for agriculture.

They have mostly been planted with forest, and are now nature reserves and recreational areas. The glacial valleys were subsequently often filled with poorly permeable sediments, yet remaining relatively low and wet areas where peat layers could develop. Sea levels rose by several tens of metres in the Holocene age, which led to the deposition of clayey sediments on top of the Pleistocene sand in a broad coastal zone. Marshy areas originated more inland because of the rising groundwater levels, those areas being at the origin of large raised bogs with peaty soils.

The three major zones in the Netherlands, characterized by their top soil (Figure 3.3), are:

- elevated sandy areas, geomorphologically formed during the Pleistocene;
- areas of the most recent coastal accretions, largely covered by clayey soils;
- a relatively low transition zone with peaty soils.

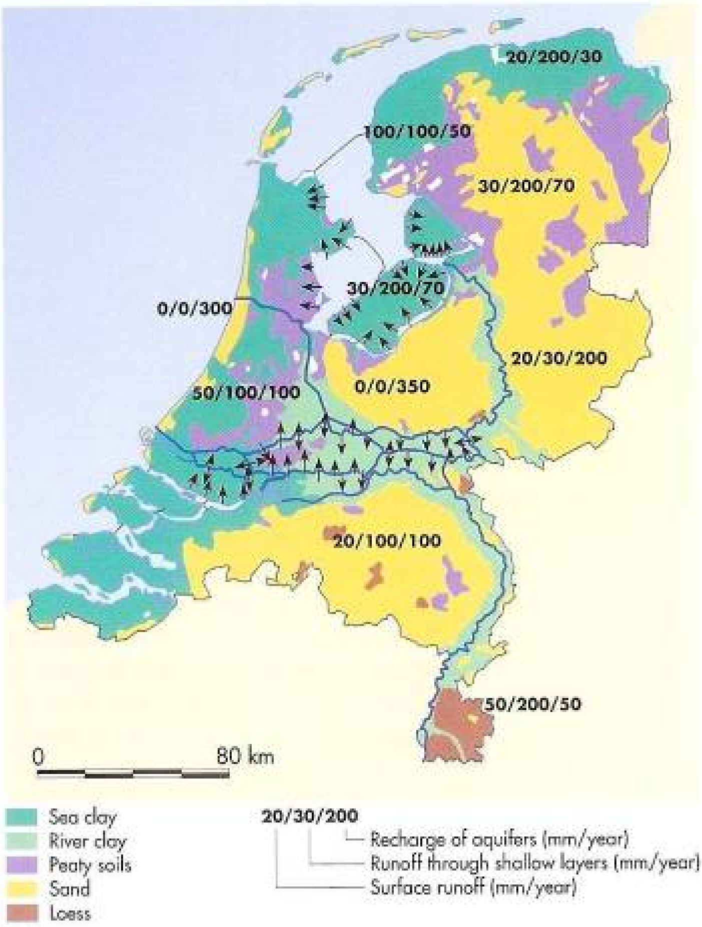

Figure 3.3 The major soil types of the Netherlands and mean annual runoff

The detailed drainage system in the lowlands of the Netherlands is almost entirely artificial and based on the discharge of excess water by pumping. Most of the surface peat layers have been excavated to supply fuel. Large lakes were created by this peat mining in the coastal regions. Many lakes were later reclaimed and made into polders, having a clayey soil (see Chapter 4). The excavated raised bogs in the higher regions were directly turned into agricultural land, drained by a system of ditches and canals. The soils of the latter land consist mainly of sand, but still with a large organic component.

The sandy regions were used for an extensive agriculture, leading to a degradation of the soils, such that vast heathlands and bare soils with shifting sands developed. The situation changed after the introduction of fertilizers some 100 years ago. Heathlands were turned into pastures and only the most infertile soils were planted with trees. Land reclamation in the sandy regions continued up to the middle of the 20th century, including extension and deepening of the natural stream systems to drain the lowlands. The development still continues with the installation of tile drainage systems.

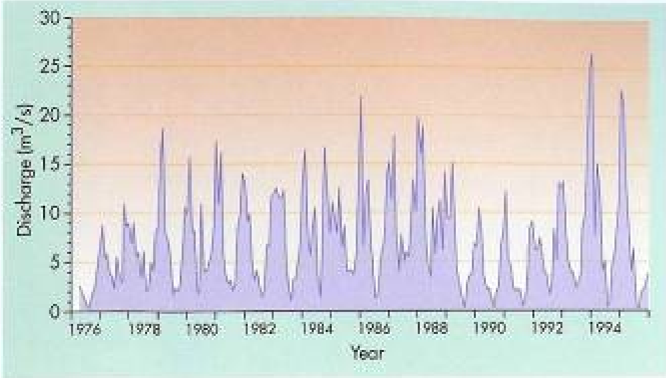

Figure 3.4 Mean monthly discharge of the river Aa

3.7 Surface water

Surface water plays an important role in the discharge of excess water, although in the relatively elevated regions with sandy soils this role is different from that in the coastal zones. Almost everywhere in the low polder areas water levels are artificially controlled by a forced discharge, but on higher grounds the drainage of water is mostly by gravity.

The smaller water courses in the sandy regions will even fall dry in normal summer periods, whereas most ditches in the polder areas remain permanently filled. A varying but mostly small portion of the precipitation excess flows directly to the streams of the sandy regions; the majority of it infiltrates into the soil and joins the groundwater. A part of this groundwater flows quickly to the drainage system, the remainder recharges the aquifers and reaches the draining streams only after a period of months or years. Due to the precipitation excess in winter periods and the water deficit in normal summer months, the mean winter runoff is in general 2 to 3 times greater than that in summer periods. Figure 3.4 shows the variation in discharge over the period 1976 to 1995 for the river Aa in the southern part of the country. The summer lows and winter peaks are quite pronounced but they vary from year to year due to the differences in precipitation. Almost no excess precipitation on the clayey soils of the coastal zone will percolate towards the groundwater in the aquifer system. Yet, an opposite flow of seepage water will reach the surface water of the deep polders in the western and central parts of the Netherlands to a maximum of 1 to 2 mm per day. This seepage water originates from groundwater which is recharged by a regional flow from the sandy areas or by infiltration from higher lying river beds or other surface water. The pumping stations, and formerly the windmills, of the polders have to pump the excess water of the winter periods, as well as a possible seepage flow having more permanent features.

Table 3.2 The highest, mean and lowest observed discharges of the Rhine (1901 to 1995) and Meuse (1911 to 1995)

River	upstream catchment area (km^2)	Discharges at the Dutch border (m^3/s)		
		highest	mean	lowest
Rhine	180 000	12 500 (1926)	2 200	620
Meuse	33 000	3 100 (1993)	230	0

The rivers Rhine and Meuse are of great importance to the hydrology of the Netherlands. The characters of these two rivers are, however, quite different.

The Meuse is a typical rain-fed river, with relatively high peak flows in winter and generally low flows in summer, whereas the Rhine has a mixed character being partly fed by rain and partly by snowmelt from the Swiss Alps. This produces two significant seasonal flow peaks: one in the winter and a much lower one in the summer originating from snowmelt. The ranges of observed discharges of these two rivers are shown in Table 3.2.

A water balance of all water passing through the country in an average year, as well as in the very dry year 1976, is shown in Table 3.3. The largest terms in the balance are by far the inflow and outflow of the river Rhine. In former times, the river water only passed through the country, being a nuisance during high level periods. But even in the recent years 1993 and 1995, the river Meuse inundated large areas and Rhine water assumed dangerous levels, causing considerable economical damage. On the other hand, the river water is used for different purposes at present. Water is now abstracted from both rivers at a rate of some 16 000 million m^3 per year, for irrigation and the abatement of salt water intrusion in the polder areas and for domestic and industrial use. Projects aimed at bringing Rhine and Meuse water to the higher lying sandy regions suffering from water deficits have been realized or are under construction.

Table 3.3 The water balance of the Netherlands for an average year and a very dry year (1976) (in mm and in 10^6 m^3)

	Average year		Dry year (1976)	
	mm	10^6 m^3	mm	10^6 m^3
In				
precipitation	750	29 100	535	20 800
Rhine (at the border)	1 775	69 000	1 065	41 500
Meuse (at the border)	215	8 400	90	3 500
other river inflows	75	3 000	40	1 500
Total	2 815	109 500	1 730	67 300
Out				
evapotranspiration	550	21 400	528	20 500
different uses	55	2 100	154	6 000
river outflow	2 210	86 000	1 048	40 800
Total	2 815	109 500	1 730	67 300

3.8 Groundwater

The groundwater hydrology is controlled by the presence and the lithology of unconsolidated sediments, deposited in a subsiding basin. The axis of the basin dips to the north-west (Figure 3.5), resulting in the largest thicknesses of the Pleistocene and Holocene formations in the north-western part of the country. Thick aquifer systems are present in the north-western part. Aquifers are less important at the margins of the basin. Tertiary and even older sediments are near

4.3 *Water management and institutional aspects*

9 Institutional and legal aspects

The legitimacy of water-related intervention was and still is an important issue in the Netherlands. This chapter summarizes the institutional structure and the present competencies of the authorities charged with water issues. It also provides brief information about the water-related laws in force.

9.1 Water administration and its background

The Netherlands is a decentralized unitary state with three main hierarchical administrative levels of water management: national, provincial and regional (Figure 9.1). At each level there are bodies with specific responsibilities: legislative and executive. A multitude of different departments or agencies is responsible for the various sectors of public policy, each deriving its authority from legislation. Water has played a dominant role in the course of Dutch history. In the 12th century local communities began to construct dikes to prevent flooding and control the water levels behind the dikes. Following the construction of dams in the tidal water courses in the 13th century, the local communities began to elect representatives to the regional meetings where the common water management affairs were discussed. These meetings formed the basis for the water boards. The election system was (and still is) based on the rule that the extent of interest defines the levy paid the costs of water control as well as participation in the administrative body. Until today the water boards still exist as specific administrative units for local and regional water management. In the 20th century the level of participation has been increased to include house owners, tenant farmers and residents because these categories were interested in flood protection and regional management too. Since the water boards take care of the water quality based on the 'polluter pays' principle, representatives of households, industries and companies participate in the administrative and executive bodies of the water boards.

In 1798 a national agency, the Rijkswaterstaat, was created in order to administer all water-related affairs at a national level. In the 19th century provincial water authorities were established and charged with the supervision of the water boards and water-related issues of the municipalities.

9.2 Institutional structure

National level

The Netherlands is a constitutional monarchy with a parliamentary system. The central Government, the executive, consists of the Monarch and the Ministers and is called the Crown. However, since the Monarch is inviolable, the ministers have full responsibility and supreme control. The ministers together form the so-called Council of Ministers (the Cabinet), chaired by the Prime Minister, which deliberates and decides on general Government policies.

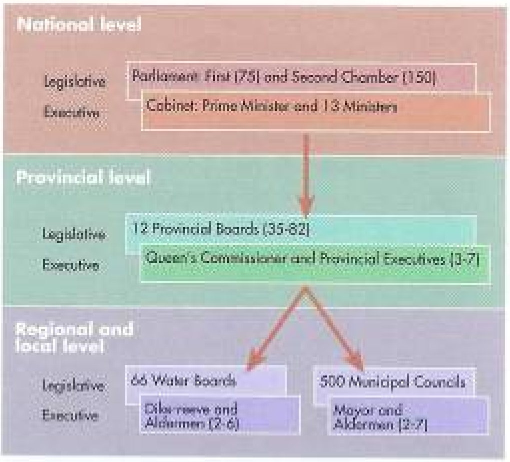

Figure 9.1 The institutional structure of the Netherlands

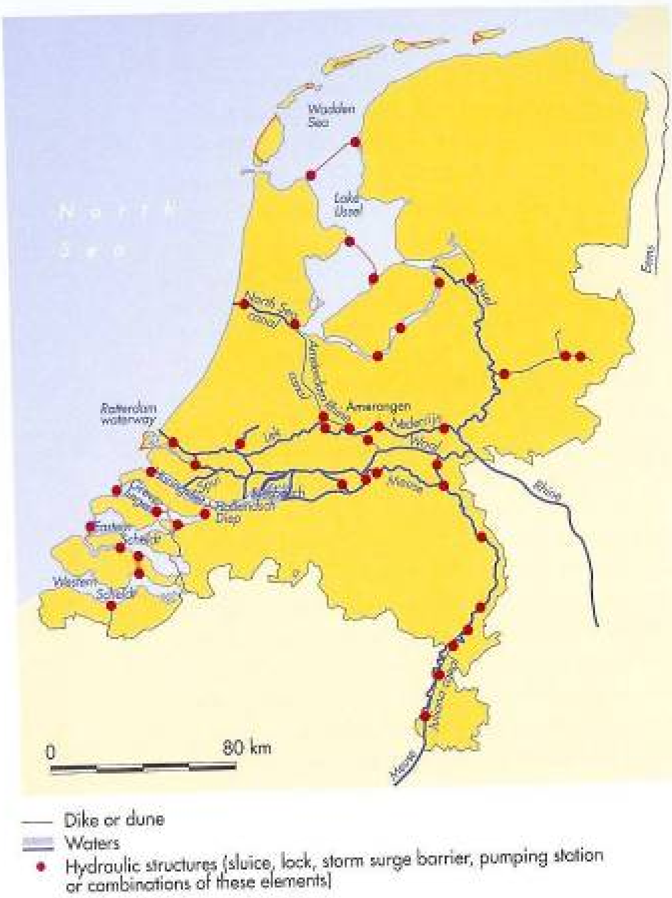

Figure 9.2 *State managed waters and infrastructure*

The Dutch parliament consists of the First Chamber and the Second Chamber of 75 and 150 members respectively. The Second Chamber, the House of Representatives, controls and approves the actual decisions of the Government. The First Chamber, the Senate, elected by provincial representatives, is the house of reflection and has the power to approve or reject a bill. The Second Chamber provides the right of amendment.

Legislative power is with the Government and Parliament together. An act may transfer the authority to issue decrees and regulations to other governing bodies, such as the Crown, Ministers, provincial authorities, municipalities, and water boards. The administrative rules given by the Crown (in practice the relevant Minister), called Orders in Council (Amvb) are quite common in the policy field of water and the environment. They prevail over provincial orders. Provincial orders prevail over orders of municipalities and water boards. The judiciary power includes the Council of State (Raad van State) and the Supreme Court (Hoge Raad). The Chamber for Administrative Justice of the Council of State is the highest judicial level responsible for administrative law. Next to this, the Council of State is the most important advisory body to the Crown with regard to judicial topics. The Supreme Court, and its subordinate courts are primarily responsible for the proper execution of the civil and criminal law.

In water management three ministries have important tasks. The Ministry of Transport, Public Works and Water Management is responsible for flood protection and water management. The water directorate of this ministry, the Rijkswaterstaat, prepares national policy on flood protection and water management. The Rijkswaterstaat supervises the implementation of the water policy by provinces and water boards. This directorate also has the operational responsibility for the state managed waters and some water retaining structures. Fig 9.2 represents the state managed infrastructure.

The Ministry of Housing, Spatial Planning and the Environment is responsible for general environmental policy; setting of water quality standards and emission standards; laws concerning air, soil and groundwater protection, waste, noise, harmful substances, radiation, Environmental Impact Statements and external safety; drinking water and sewerage; and spatial planning (land use).
The Ministry of Agriculture, Nature Management and Fisheries is responsible for general policy on agriculture, nature management, fisheries, rural areas and outdoor recreation; legislative policy concerning nature conservation with regard to species and areas.

Provincial level
The organization and tasks of the 12 provinces are ruled by the Province Act. The administrative bodies at provincial level are:
- the Provincial Council: the elected body of 45-85 members (depending on the number of inhabitants);
- the Provincial Executive: nominated by the Provincial Council from among their members;
- the Provincial Governor: chairman of the council and the executive board, nominated by the national Government.

The water management at provincial level was formerly performed by the provincial water management department. Recently these departments have merged with the provincial environmental departments.
With the exception of the state managed infrastructure, the twelve provinces define and supervise the responsibilities and activities related to flood protection and water management.
Since the Pollution of Surface Waters Act came into force in 1970, the provinces no longer have virtual autonomy in specifying the tasks and competencies in water management; the State now plays a leading role in the assignment of tasks and competencies in qualitative surface water management. The same system was continued in the Groundwater Act, the Water Management Act, the Soil Protection Act and the Flood Protection Act. The Water Board Act defines that local and regional flood protection and water management is excercised by the water boards. The provinces can make policies of their own but will also receive directives from the national Government and have to ensure implementation by the municipalities and water boards.

Moreover the provinces coordinate the policies of the different sectors of government, such as water management, environment, nature conservation, housing, physical planning and transport.

The provinces have created the Interprovincial Platform, in which organization common views and statements of the provinces are formulated.

Regional and local level
Water boards
The water boards became the competent regional water authorities in the thirteenth century. Since the fifteenth century the local embankments and polders were administered by water boards. In time thousands of water boards existed.

After the storm surge disaster in 1953 the number of water boards decreased (see Table 9.1). The scaling up process can be illustrated by the province of Groningen. The map of Figure 9.3 represents the 74 water boards in 1978 and the four interprovincial water boards in 1996. The present 66 water boards are organized according to the Water Boards Act. The water board organization comprises:

- the General Assembly, elected by specific groups such as owners of real estate, wastewater dischargers, residents;
- the Executive, nominated by the Assembly;
- the Chief Executive, chairs both bodies and is nominated by the national Government.

Table 9.1: Number of water boards

Year	1946	1969	1978	1990	1998
Number of water boards	2500	1000	400	129	66

Whereas the central Government, and the governing bodies of the provinces and municipalities are so-called 'general democracies' the water boards are 'functional' governmental bodies. The election of general democracies is based on the principle 'one man, one vote'. A functional democracy such as the water board is based on the rule 'interest-payment-say'. The distribution of seats in the water board among landowners, residents and wastewater dischargers is defined by this rule. As the situation differs in each region, the composition of the water boards varies. The provincial authorities define and supervise the tasks of the water boards under approval of the national Government. The water boards are responsible for flood protection, and water quantity and quality management in their territory, in some cases together with the management of waterways, bridges and roads. As many provincial borders do not coincide with the hydrological/hydraulic borders of the water boards, interprovincial water boards were created.

The water boards are united in the Union of Water Boards.

Municipalities

The tasks and organization of the 500 municipalities are governed by the Municipal Act. Municipal organization comprises:

- the Municipal Council: an elected body of 7-45 councillors;
- the Municipal Executive: a number of Aldermen appointed from among their members by the Municipal Council.

The Mayor is chairman of both councils, is nominated by the national Government and appointed by the Crown.

The water management task at municipal level is limited to the management of sewerage systems performed by the local public works department. The municipalities promote their common views through the Netherlands Association of Municipalities.

Drinking water companies
Drinking water supply is taken care of by some 25 drinking water supply companies. Although they have a privatized structure, the shares are owned by public authorities (provinces and municipalities). The drinking water companies are united in the Netherlands Waterworks Association (VEWIN).

9.3 Water legislation

There is a wide variety of water legislation. Apart from the fundamental statement in the Constitution, the water laws can be divided into five categories. The first one deals with the institutional framework and the organizational aspects, the second one with aspects of (integrated water) policy, the third with aspects of infrastructure. The fourth, specific, category is drinking water, and the fifth category pays attention to legislation related to water issues.

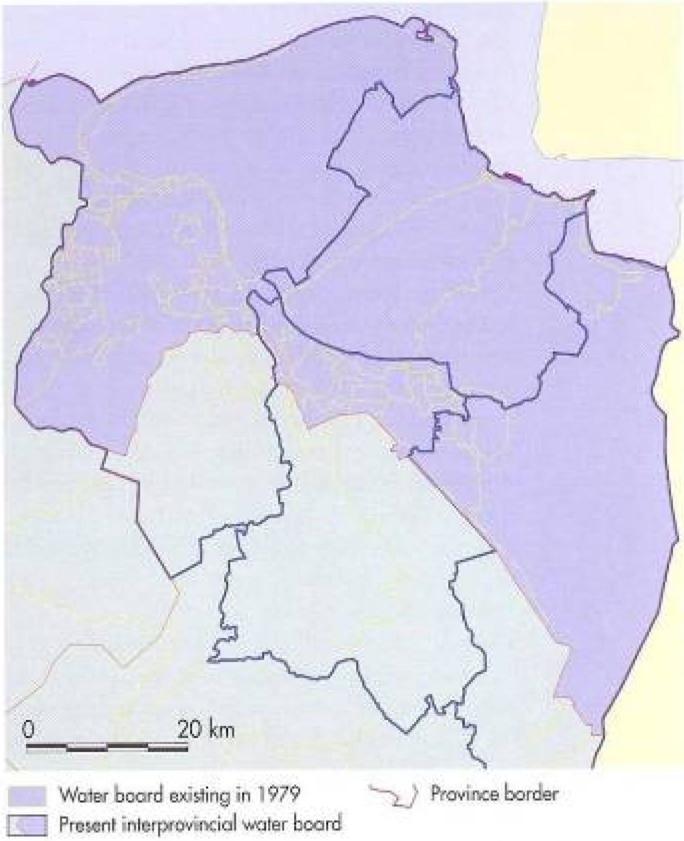

Figure 9.3 *The integration of water boards in the province of Groningen: the 78 water boards existing in 1979 are incorporated in the four interprovincial water boards of 1997*

Fundamental statement
Article 21 of the Constitution of 1983 states that 'the inhabitability of the country and the protection and improvement of the environment' are public tasks. Not only water management but also environmental management, nature management and physical planning are the responsibility of public administration.

Institutional and organizational aspects
Constitution
Article 133 of the Constitution defines the creation, termination and regulation of the responsibilities of the water boards. These duties are carried out by the provinces.

Water Administration Act 1900
Among various different topics, this Act includes one that deals with the organization, tasks and competencies of the Rijkswaterstaat.

Water Boards Act (1992)
The Water Boards Act contains rules about the creation of water boards by the provinces, especially regulations concerning the composition of the Water Board's Council, the competence to issue ordinances, and financing. The responsibilities and competencies of the water boards are directed towards tasks given them by the provinces.

Aspects of integrated water policy
Water Management Act (1989)
The Water Management Act defines the planning structure for water management by the Government agencies at different levels and gives rules for the quantitative management of surface waters.
It provides the following policy instruments: planning; permissions; registration of abstractions and discharges; water covenants; level decisions; and charges.
The planning structure of this Act is of major importance because it presents an integration of national and provincial plans based on the Pollution of Surface Waters Act, the Groundwater Act and the Water Management Act itself. It also includes statutory cross-references with spatial planning and environmental planning.

Pollution of Surface Waters Act (1970)
The main objective of this Act is the pollution control of all surface waters for which it provides a framework for a two-track policy: the reduction of emissions and the improvement of water quality (emission approach). The instruments of the act are: the issue of discharge permissions; the setting of standards; and the use of levies.

On the emission side it is forbidden to discharge into water unless a permission is given.

There is a levy on discharges, especially organic waste and heavy metals, which is used to recover the costs for wastewater purification and subsequent discharge. The primary permitting authorities are the national Government or the provinces, which delegate their responsibilities to the water boards.

The Pollution of Seawaters Act is a special Act which was made for the North Sea area (1975).

Groundwater Act (1981)
The Groundwater Act covers all abstractions by means of pumping works. The provincial government is responsible for the instruments provided by the Act. These are: abstraction permissions; abstraction registration; duty to report; and levies. All abstractions of more than 10 m^3/hour usually require a permission.
This Act concerns groundwater quantity only, although qualitative aspects are incorporated where the recharge of aquifers is concerned. Other quality aspects are dealt with in the Soil Protection Act.

Soil Protection Act (1987)
The act contains a general duty to prevent, and if necessary, to clean up soil and groundwater pollution. This Act provides the structural basis and the necessary

administrative instruments for the implementation of the soil and groundwater protection policy. It should be noted that, anticipating this act, a Soil Clean-up Interim Act already became operative in 1983 for the regulation of soil clean-up operations. The latter was incorporated in the Soil Protection Act in 1994.

The Soil Protection Act distinguishes two levels of protection: a general level and a specific level. Both protection levels differ from each other only in the level of acceptable risk for soil pollution caused by certain activities.

The general protection level is formed by regulatory measures set by the national Government. These rules concern the regulation of activities that may lead to pollution or impairment of soil and groundwater, and the formulation of soil quality standards.

To illustrate the system of the orders in Council, the administrative rules given by the Crown, the orders based on this law are given below:
- application and spreading of manure on soil (1987)
- discharge of liquids into soil and groundwater (1990)
- application and spreading of sewerage sludge and organic household waste (compost) on soil (1991)
- dumping of solid waste materials (1993)
- storage of petrochemical products in underground tanks (1993)
- artificial recharge of aquifers (1993)
- eaching standards for building materials produced from recycled waste (1995)

In addition to the general protection level, a specific protection level must be implemented in soil protection and in groundwater protection areas used for water supply. In these areas potentially harmful activities are either not tolerable or additional preventive measures are necessary. The acceptable risk level of pollution is lower in these areas. At present, the groundwater protection areas cover about 1 400 km^2, i.e. approximately 4% of the Netherlands.
Since 1994 the regulations concerning soil and groundwater protection areas are part of the Environmental Protection Act.

Legislation concerning sewerage collection and treatment
Sewerage management is not regulated by formal legislation, but by provincial and municipal ordinances. In the Environmental Protection Act an obligation is put on the municipalities to prepare sewerage plans.

Acts concerning (water) infrastructure
Act concerning State managed infrastructure (1996)
All activities which are not in line with the normal use of state managed infrastructure is subject to a licence: e.g. cables, wires and pipes in navigation canals, rivers and dikes.

Act on polders and embankments (1904)
This Act requires a permission to be granted by the Ministry of Transport, Public Works and Water Management (Rijkswaterstaat) for reclaiming land from the sea, estuaries and rivers.

Rivers Act (1908)
The Rivers Act serves the 'interests of public streams and rivers'. Until recently, this rather vague formulation included mainly the protection against river flooding by safe discharge of water and ice. For all activities in the summer and winter bedding that increased the high water levels, 'hydraulic compensation' is required before a permission is granted. In 1991 the scope of the Rivers Act was expanded to include other interests such as nature, landscape and recreation.

Delta Act (1958)
This Act formulates the principles for the protection of the Netherlands against storm surges by closing estuaries and reinforcement of the dikes and dunes.

Delta Act major rivers (1995)
The 1993 and 1995 river floods gave rise to this specific act, enabling strengthening of 150 km river dikes along the major rivers in the period 1995-1996. The Act replaced the usual cumbersome time consuming procedures prescribed in 19 laws by one single decision and one possibility to appeal. Thanks to this emergency act the weak dikes were strengthened in time.

Flood Protection Act (1997)
In a sinking country threatened by rising sea and river levels, it is necessary to maintain the flood protection level achieved by the Delta Plan and by dike strengthening.
The Act contains a 'finger on the pulse' mechanism, by which each dike authority has to report about the conditions of its dikes every five years. The reports of the dike authorities are stepwise summarized by the provincial and national Governments and sent to Parliament. The Act also contains regulations about the present dike strengthening.

Legislation for drinking water
Legislation with regard to drinking water supply can be found in several acts and regulations because different aspects are concerned: source, quality and protection of the raw material as well as production and distribution. Drinking water has two main sources: groundwater and surface water. Relevant acts are: the Groundwater Act, the Soil Protection Act and the Water Management Act. These last acts create the conditions for water resources development and protection.

Drinking Water Supply Act (1958)
This act is directly concerned with the provision of water and its quality and regulates the supervision of the water producing and distributing companies in the interest of public health. It contains regulations on supply conditions, quality standards, organization and planning.

Legislation related to water issues
For the performance of the water authorities, related water legislation is also of the utmost importance. Here the legislation in the field of spatial planning and environmental and nature protection is mentioned.

Spatial Planning Act (1965)
The Netherlands has a well established system of spatial planning on three levels of administration, based on the Town and Country Planning Act of 1965, as amended in 1983. The municipalities make the most binding and country plans in which the potential uses of all areas are indicated. The provinces adopt regional plans and the national Government issues a policy document on spatial planning at a national level almost every ten years.

Environmental Protection Act (1993)
The first Dutch legislation concerning the environment was the 1875 Nuisance Act. Businesses or private individuals need licences for activities hindering the actual use of space, water and soil. The licences prescibed conditions to be respected. Since 1970, several environmental acts have been introduced dealing with water, air, soil, waste products, etc.

The basis for integrated environmental legislation was laid by the 1979 General Environmental Provisions Act which in turn formed the basis of the Environmental Protection Act which came into operation in 1993. This act provides the legal framework for the environmental plans and programmes of central government, the provinces and the municipalities and lays down the regulatory procedures for planning and permissions.
The environmental aspects of a great number of industrial activities are regulated on basis of the Environmental Protection Act.

Nature Conservation Act (1967)
This act provided extra protection to ecologically important areas by designing natural monuments. Large areas of the Wadden Sea and the Rhine-Meuse-Scheldt delta have been given this status. Presently this Act is being replaced by a new one, which will introduce nature reserve planning and in which most protective measures will be allocated to the provincial level.

4.4 *Waterboard Hunze and Aa's*

Waterboard Hunze en Aa's is responsible to ensure a safe environment regarding water management for the north-eastern part of The Netherlands. Waterboard Hunze en Aa's is the operational water manager for the area and at the same time responsible for strategic water decisions. The management area is 213,000 ha and is home for 420,000 inhabitants. Currently, Waterboard Hunze en Aa's is evaluating its long-term strategic mission including preparation for climate change. More data on Waterboard Hunze en Aa's can be found in Table 1.

Table 4.1: Data waterboard Hunze en Aa's

Surface area	213,000 ha
Highest point	+ 27 m NAP
Lowest point	- 3 m NAP
Length sea dike	28 km
Length other dikes	500 km
Length canals	3525 km
Soil types	Clay, sand, peat
Catchment	Part of the Eems-catchment (15%)
Inhabitants	420,000
Staff	375
Location	Map (Hunze en Aa's = red)

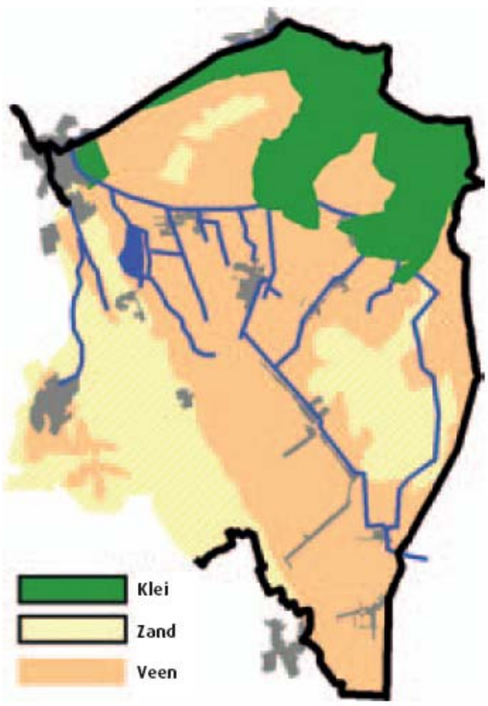

Figure 4.1: Soil types Waterboard Hunze en Aa's (green = clay, yellow = sand, orange = peat, blue = water)

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