RHINELAND ON THE WAY TO ITS THOUSANDTH ANNIVERSARY OR WATER-ADMINISTRATION IN THE NEXT 100–200 YEARS

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ABSTRACT

An inventory is made of the effects of sea level rise and expected climatic change on the level of the district water authorities in the Netherlands and especially the "hoogheemraadschap" of Rhineland in the next 100–200 years. Special attention is paid to the effects on land utilization, coastal defence and water control. The first is hard to describe by lack of research, the second can already be determined in terms of cost; the third can be described in its effects on brackishness and water provision with indication of policies and measures to be taken. Preliminary conclusions are that larger efforts on coastal defence - even with present techniques - will be a realistic answer in terms of cost. The foreseen increase of brackishness in area and salt concentration, will give a significant extra need for fresh water. High cost and even higher risks have to be expected with regard to measures to neutralize the effects of a water surplus in winter and a growing water shortage in (late) summer, while the cost will further grow. Because of the effect a larger area must be drained off and water has to be raised higher as the Netherlands will sink in relation to the North Sea.

KEYWORDS

Sea level rise; climatic change; district water authority; Rhineland; water management.

INTRODUCTION

In this paper certain developments have been described, being of interest to the water administrator in the next 100–200 years. They are linked to the fact that the "Hoogheemraadschap of Rhineland", being the oldest district water authority in Holland, has held responsibility for water administration in the central part of Holland since the Middle Ages. First, we will view the significance of the effects of sea level rise and then of climatic change, for the regional water administrator in this low-lying densely populated delta. What is their consequence on coastal defence, the fight against increasing brackishness and water provision? Now and then measures have been indicated, partly already expressed in terms
of cost, however always with the question in mind "can the Netherlands be assured of keeping their feet dry by intensifying existing methods and techniques or will the risk become so high that introduction of new technologies will be a must, or even that the most realistic scenario becomes the designed surrender of the delta?".

THE "HOOGHEEMRAADSCP" OF RHINELAND

The "hoogheemraadscp" of Rhineland (Rhineland) is one of the approximately 150 district water authorities which are responsible as regional authority for water administration in the Netherlands.

Rhineland administers an area of about 1160 km², roughly situated between the North Sea Channel in the north, the line Amsterdam-Gouda in the east, the line Gouda-The Hague in the south and 50 km of sand dune coast as a border with the North Sea in the west.

There are 48 municipalities partly or fully located in Rhineland, while Rhineland itself lies in two provinces, namely North and South Holland. Approximately 1.25 million people live in this area.

Rhineland's responsibilities can be defined as follows:
- coastal defence
- water quantity control
- water quality control.

Provision of drinking water is commissioned to private companies, while the sewerage systems management is the responsibility of the municipalities. In 1989 about 120 million guilders were spent: a good 80% on water quality control and 20% on water quantity control and coastal defence.

SHORT HISTORY

Rhineland was established at the Rhine estuary as this existed until 1163. This estuary lay approximately 30 km north of the present Rhine estuary at the location where later the present village of Katwijk was built.

Due to combination of various factors, the estuary silted up. Consequently, residue water, partly flowing off via the "old" Rhine could scarcely, if at all, be discharged into the sea. In those times this caused floods in a large part of the central area of Holland. This part of Holland consisted, otherwise than today, of very extensive peat-bog (well above sea level) and was strongly wooded, a fact which determined later on the name of this country, namely "Holt- or Houtland" (woodland). Holland as we still call it now.

An attempt to find a solution for this silting up of the Rhine estuary was made in 1165 by laying a dike through the Old Rhine, at the Holland-Utrecht border. In this way at least the supply of Rhine water was stopped and the problem solved - for Holland. For Utrecht, lying upstream, it was the beginning of a great water surplus problem. Holland and Utrecht, now provinces of the Netherlands, were then a county and a diocese. The result of this shift of the water surplus to Utrecht was an "international" conflict. After unresolved argument the count and the bishop could only settle their differences by submitting them to Emperor Barbarossa, well known from history, who settled the dispute with a real "judgement of Solomon". This is not the place to expand on the content of the judgement but it is sufficient to say that this judgement determined the existence of Rhineland as district water authority. Indeed, it was determined to such an extent that the imperial decision defined the relationship between Rhineland and its neighbouring water authority until 1956. It was even brought up as the first rule in the field of international water legislation by 10 Dutch water administrators in a still-running lawsuit against the salt dumping of the French potash mines in the Alsace.

This short history shows that I am justified in linking the 1000 years of...
existence of Rhineland with water administration in the next 100-200 years.

I also needed a short historical introduction to make clear that human interference in the environment, in particular in the water environment, has incredible consequences over time. But I also wish to indicate that from a technical and organizational point of view the Dutch have found their own answer in the establishment of water boards which - after more than 800 years - are still responsible for water administration. These organizations are involved in the fight against water, but also in water provision, in the necessary amounts and quality. Together with the national and provincial authorities the water authorities face the challenges of the future, including the great challenge of controlling the effects of sea level rise and climatic change.

HOLLAND NOW

The area of Rhineland together with that of its neighbours, the "hoogheemraadschappen" of Delfland and Schieland, typify the heart of Holland. The area only represents 5% of the total area of the Netherlands, but on these 1800 km², appr. 2,700,000 people live and work (i.e. 17.5% of the total population). Large cities such as Amsterdam, Rotterdam and The Hague are situated here, together with the largest airport (Schiphol) and largest seaport (Rotterdam).

Besides an industrial and commercial centre located here, there is an enormous glasshouse horticulture and, certainly not to be forgotten, an important centre of bulb cultivation.

In the Middle Ages the country lay on an average 1-2 meters above sea level. Due to drainage followed by settling of the soil, peat cutting and reclamation, it now lies up to 7 m below sea level. This depth makes the area very liable to brackishness. Determined by the Rhine, both geographically and for its water supply, it is climatically regulated by a mild sea climate with a precipitation of 820 mm per year.

EXPECTED DEVELOPMENTS

General

Even disregarding for the moment a possible change in climate and rise in sea level, the area will change considerably in the next decennia. In the recent past a large growth in population has occurred; an increase is also expected during the period up to 2025. This increase will involve a further extension in building development.

Besides population growth, the expected economic growth will also have consequences for construction. Roughly speaking on the basis of present expectations, the built-up area within Rhineland will increase by 25%.

It is clear that this development will influence water control in this area. If storage capacity remains practically the same, surplus water will have to be drained off faster.

Population and economic growth have in the past always proven to bring greater requirements of drinking water and water for industrial purposes. In view of all the plans to handle water more efficiently it is not clear whether the now expected growth will have the same effect. However, to be on the safe side, it seems appropriate for the moment to take into account a moderate rise in need of water.

Without further intervention, the growth mentioned would certainly lead to greater pressure on the quality of air, soil and water.

The question is to what extent can we meet this pressure with the now intended measures or can we even lessen the pressure which already exists? In any case,
we must face the risk. Extension of administrative systems also means an increased risk of failure of these systems.

**Climatic change - rise in sea level**

As mentioned before, regional developments have already been set in motion for the coming 25 years.

Over and above these developments there are the global consequences of possible rises in sea level and climatic changes in the long run (100-200 years). Leaving the causes of climatic change and sea level rise for what they are and even with limited view on the probability of these phenomena, it is possible to draw a picture of what the water administrator will have to deal with. There are a number of points I would like to mention here. In turn I will review the effects of climatic change and sea level rise on:
- land utilization;
- coastal defence;
- water control.

**Land utilization.** It is most likely that in the case of climatic changes considerable changes in land utilization would occur. Assuming for Europe an average temperature rise of 2 °C with differentiation according to area, economic and population pressure on now moderate and cold zones can be expected to increase. Projected onto the Dutch situation this will result in further intensification.

Regarding a number of scenarios which have now been worked out it is remarkable that this aspect has (as yet) scarcely if at all been taken into account. This in itself is not surprising in view of the fact that predicting changes in cultural pattern as a result of climatic changes, is a risky business. However, it seems appropriate to include the possible influence of such changes in the calculation models now used by implicating a few hypotheses on changes in land utilization.

**Coastal defence.** Expected change in sea level is a clue which gives some idea about coastal defence and hence what Rhineland will have to face. It is important to point out here that the sea level has already been rising for thousands of years. A large amount of data has been collected on the subject and at least in the area of the Holland coast its effects have been quite well observed.

The question is therefore not whether, but how great, a rise can be expected for the next century and what this will mean in terms of actions to be taken and their cost. A number of alternative strategies to control the sand dune coast have recently been considered with their consequences by the Ministry of Transport and Communications on the basis of a number of premisses concerning the expected rise in sea level.

Firstly a rise was considered similar to the rise which affected the Dutch coast in the 20th century, namely 0.20 m/century. Then effects were investigated on the basis of a 0.60 m/century and 0.85 m/century rise.

Based on these premisses, four alternative lines of policy were worked out, namely:
1. seaward defence;
2. maintaining the present situation;
3. selective withdrawal (today's policy);
4. withdrawal.

It is not necessary to discuss at this moment these alternatives in detail. In summary it can be said that on the basis of a rise in sea level of 0.60 m (the most realistic premiss), the difference in total cost to fight erosion over 353 km coastline between the maximum and the minimum alternative would only be 50 million guilders per year. The seaward alternative would cost a maximum of 80 million guilders yearly (roughly 2-3 times the cost of today's policy). Even a more unfavorable premiss of 0.85 m in the next century, combined with stronger winds and higher waves and an unfavorable wave direction, showed a
manageable cost pattern. Should the rise in sea level progress to a value of 2-5 m in the 22nd century, other models will probably have to be considered, for instance the alternative of strategic retreat.

In view of its hypothetical nature I will omit to discuss the effects of this alternative. Assuming a rise of 0.60 m/century until the year 2100 an increase in cost will indeed occur, however this increase will be limited, even considering today's methods and techniques.

Water control. The consequences for water control will probably be much more important. I would like to highlight the following aspects: increasing brackishness, general provision of water and corrective measures.

Increasing brackishness. Large areas in the western part of the Netherlands experience difficulties to a greater or lesser extent with salt seepage or salt water penetration via the river estuaries. Rhineland also faces this problem. The cause of this problem can to a great extent be attributed to human interference in nature during the last centuries. Around the year 1000 land lay approximately 2 m above sea level. Intensive de-bogging, followed by mill drainage and setting and oxidation of the soil as a consequence of that drainage, caused the land to sink below sea level, sometimes by as much as 7 m. These actions have caused or increased brackishness.

Measures taken during the past decennia to improve drainage, mainly for the benefit of agriculture, have increased the problem further. In many deep-lying "polders" 5-7 m below sea level, water is drained off with a concentration of 500-1000 mg Cl⁻ per litre.

Two major consequences of sea level rise can be distinguished. Firstly, the area of land affected by salt seepage will increase. For an extreme rise of sea level of 5 m it has been calculated that the total area in the Netherlands subject to salt seepage will increase from 1/3 to approximately 2/3.

On the basis of a 0.6 m or even 1 m rise in sea level, this effect will certainly be limited. But still the problem area will grow larger. Also - and this may form a greater problem - salt concentration in already sensitive areas will increase. The first data show indications in the direction of a 5 to 10 % increase. Consequently the need for fresh water to fight brackishness will strongly increase.

Rhineland already requires a considerable amount of fresh water yearly. An average of 208 million m³ water is let in, 30% of which can be attributed to fight brackishness. The water is mainly drawn from the Rhine. A rise of 1 % salt seepage means an extra need of 12 million m³ of fresh water to be let in. An increase of 5-10 % will consequently imply a significant need for fresh water. This will furthermore lead to a significant increase in pumping capacity.

Provision of water. Apart from increasing brackishness and its consequences toward water requirements, it seems a good idea to investigate how water management will be affected when a change in climate will occur at the same time. It has already been indicated that salt seepage will occur in a larger area. Sea level rise is also responsible for an increase of areas to be drained. For the Netherlands the area to be drained could increase from approximately 8900 km² to 10,300 km², or an increase of 15 % in the next century. This however will not affect Rhineland which is already fully drained today. Apart from extension of the areas to be drained there is the problem of the additional raising height of approximately 0.6 meter over 100 years. This raising height will require large new provisions in view of the fact that existing pumping capacity will not be sufficient to meet demands.

On commission of the Ministry of Public Housing, Environmental Planning and Protection, the possible consequences have been investigated by using models.
The investigation is carried out on the basis of data on requirements for drinking water, industrial water and water for agricultural use, and drainage of water (through the rivers). It researches the extent to which changes in the relationship precipitation-evaporation and water supply to the rivers will cause pressure points. Besides the present situation 4 scenarios are distinguished. For each scenario the winter and summer situation is defined. The results of this still very rough model-research require further study. However they already give important indications of what water authorities might expect.

For example the precipitation surplus in the winter may increase considerably. This makes the risk of polder flooding in wet periods greater. On the other hand we will experience a growing shortage in precipitation and consequently ditto water-supply needs in (late) summer. To what extent the river Rhine will be able to cover this need both qualitatively and quantitatively, urgently requires further study.

Summarizing, the water authorities will be confronted in the coming century with:

- an increase of the areas which must be drained;
- an increase of the areas suffering from salt seepage;
- an increase of salt concentration;
- an increase of surplus water in winter;
- an increase of water shortage in (late) summer;
- an increase of raising height.

**Corrective measures.** Corrective measures should be directed in two ways:  
**Water storage.** Enlargement of water storage, both for reception of surplus water in winter and for reducing the shortage of water in summer, will be of the utmost importance. On regional scale this can be done by (re)creating wetlands in (peat)polders; on a national scale this can be realised by storage of water in the Ijssel lake. In case the river Rhine wouldn't cover all the needs in summertime, it is perhaps even possible that in a growing united Europe, Switzerland and Germany offer assistance by storing water in (spring or) early summer.  
**Supply and drainage systems.** Extension and adaptation of those systems will be necessary; both regional and national. For the regional water authorities the emphasis will lay on increasing the capacity of canals and pumping stations. In the latter case to realize the first will become more and more a bottleneck in a densely populated area as Holland is. Further heightening of dikes is risky and can only be done at high cost. Digging additional canals or even broadening existing canals is, at least for the main systems, nearly impossible due to a lack of space in these areas. Although financial indications cannot be given yet, we may take that the cost for these measures will run into a multiple of the extra cost for coastal defence.

In view of the extent of the problems brought forward here, it is obvious that intensification of present measures and maintaining present techniques will not be sufficient. Whether the system can be adjusted and remain financially viable is one question. Even more important is the question: will the total system become so vulnerable that in fact assumptions governing the special lay-out of the Netherlands as a whole need to be reconsidered. But even this is probably not enough. The position of this delta and its relation to the hinterland, the crucial role of the river Rhine, and the expected economic and cultural changes, and the changes in land utilization, require an international approach, especially in view of a Europe moving towards unification.

**CONCLUSIONS**

In the next 100-200 years the water authorities will have to deal with several
important developments. On the basis of a large number of premisses, the following conclusions may be (carefully) drawn.

Measures linked with larger efforts on coastal defence, taken as a result of a rise in sea level, may demand an approximate doubling of present cost. This is calculated on the basis of present methods and techniques and does not lead to drastic policy changes - at least until 2100.

Brackishness, already forming a considerable threat to earth-linked agriculture and horticulture, will increase by 5–10%. This will mean a significant extra need of fresh water and increase in wash-out cost.

The rise in sea level will mean larger areas to be drained, compared to the present situation. For the Netherlands this could mean an increase of approximately 15% of the area now drained, while raising cost will increase for already existing areas.

Assuming an average rise in temperature of 2°C, a considerable water shortage in (late) summer could occur. Regional water storage will not be enough. Measures on a (international) scale will be necessary to ensure a sufficient water supply of adequate quality. Again, large amounts of money will be involved.

Quite apart from cost and how to control them, fighting the consequences of a rise in sea level and a climatic change (by using the present methods and techniques) will involve serious risks for the polders.

Initial studies give some indication on a national scale. More detailed research must now follow quickly into the problems of regional authorities.

Research into spacial effects of cultural changes in Europe as a result of climatic changes, isurgently needed; as well as further investigation of the water supply of the main rivers, especially the river Rhine, under these conditions.

REFERENCES


