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THE DSS 'PLANNING KIT' AND ITS APPLICATION IN THE SPANKRACHT* STUDY

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ABSTRACT: The Netherlands is expected to face severe consequences of climate change. A rise of the average sea level with 60 cm and an increase with about 20% of the extreme discharges of the rivers Rhine and Meuse might be expected ad the end of this century. This requires measures. Therefore a policy analyses has been carried out to determine which strategy could be followed to maintain the current safety standards. In this policy analyses about three hundred spatial measures were evaluated. To support the work a Decision Support System has been developed: the Planning Kit. This article presents the Planning Kit and illustrates working with the Planning Kit. In the Spankracht study the Planning Kit proved to be an indispensable instrument in the evaluation process.

Key Words: Decision support systems, safety against flooding

INTRODUCTION

Climate change has become an important issue for a lot of nations. Also in the Netherlands climate change is expected to cause severe consequences. A rise of the mean temperature with 1 – 4°C by the end of the century might be realized, depending on the rate with which climate changes develops. In the medium scenario a temperature rise of 2°C is expected. For North West Europe a considerable sea level rise and also a significant increase in rainfall and extreme river discharges is expected. In the Netherlands a rise of the average sea level of 60 cm and an increase with about 20% of the extreme discharges of the rivers Rhine and Meuse are expected in the medium scenario. Without large scale measures the flooding safety standard in the Netherlands would drop to an inadmissibly low level (Können et al. 1997; Kors et al. 2000; Commissie Waterbeheer 21e eeuw 2000).

The areas around the dutch rivers are protected by dikes. A further raise of these dikes encounters all kinds of difficulties. For instance in the western part of the Netherlands peat in the subsoil makes it difficult to provide a solid foundation. And where

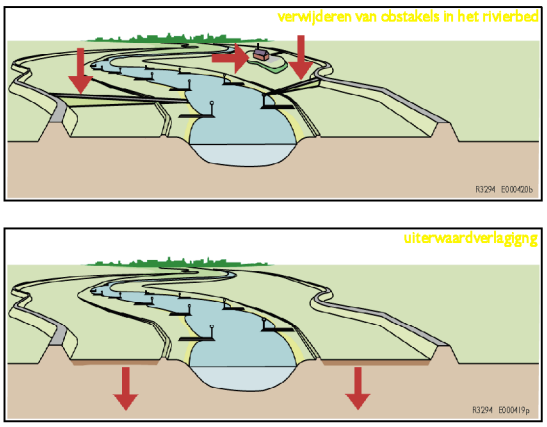

Fig. 1 Examples of measures: removal of obstacles in the floodplain (upper) and excavation of the floodplain (lower)

will the ongoing dike enlargements end? It is a viscous circle of an increasing problem and further and further enlargements of the dikes. Therefore the governments of the nations along the Rhine and Meuse have decided that increasing discharges are preferably encountered by spatial measures (returning

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Note: Discussion on this paper is open until June 1, 2005

* The Dutch word 'spankracht' has a meaning in a sense of 'a capacity of transformation'.

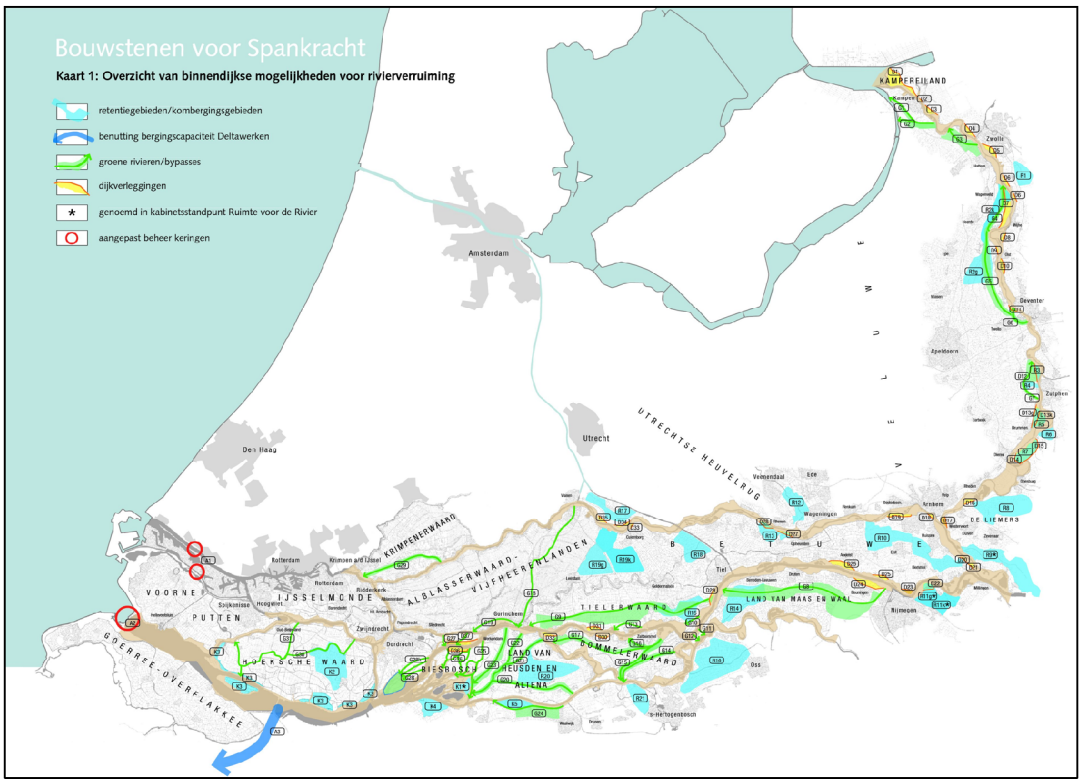

Fig. 2 Map of all considered large-scale inland measures***

room to the river) and so avoid a rise of the current design flood levels. In a densely populated country as the Netherlands this is quite task. It is not just a technological problem, it is even more a spatial planning problem as well as a social and economical problem.

Therefore in the Netherlands a policy analysis was carried out to determine the best long-term strategy. Important questions were:

- If large-scale spatial measures should be taken, where is this preferably done?
- Should the subdivision of the discharge of the Rhine over the three Rhine branches (Waal, Nederrijn and IJssel) be changed?

The policy analysis Spankracht study evaluated about three hundred different measures. To support this huge analysis a Decision Support System (DSS) was developed: the Planning Kit**.

EVALUATED MEASURES

As already stated, in the Spankracht study about three hundred measures were evaluated. The considered types of measures are (Projectgroep Spankrachtstudie 2000b):

- Rather small scale measures within the riverbed:
  - Dredging in the mainstream of the river.
  - Lowering of groynes in the mainstream of the river.

** The Planning Kit was developed by WL | Delft Hydraulics under the authority of Institute for inland water management and waste water treatment (RIZA).

*** Translation of types of measures in Figs. 2 and 6: Retentiegebieden/kombergingsgebieden = detention, Huidig landgebruik = maintaining land use, Herinrichting = change of land use, Benutting bergingscapaciteit Deltawateren = using storage capacity of the lakes in the south western delta area, groene rivieren/bypasses = green rivers/bypasses, dijkverleggingen = relocation of dikes, uiterwaardvergraving = excavation of floodplains, zwaar = heavy, matig = medium, licht = light, Verdiepen zomerbed = dredging in mainstream

- Removal of embankments along the mainstream of the river.
- Excavation of the floodplains, six alternative types of excavation were considered.
- Removal of obstacles in the floodplains (flood free industry terrains, land abutments etc.).

o Large scale inland measures:
- Detention; reservation of inland areas along the rivers to store some of the discharge only during extreme large river discharges. In average situations the existing land use (mostly meadows) may be maintained.
- Development of new small scale branches (bypasses around cities) or large scale branches, also called 'green' rivers. The term green rivers is used because most of the time these braches don't carry water. These branches are only to be used during extreme large discharges.
- Inland relocation of dikes along the floodplains. This type of measure in fact widens the already existing floodplains.

The hydraulic effect of every individual measure was calculated with a calibrated and verified hydraulic model (WL & RIZA 2002 a, b, d; WL & HKV LIJN IN WATER 2000 a - e). Also were effects determined such as costs, area of floodplain excavation, amount of excavated polluted soil, loss of agricultural land, gain of nature, number of removed houses, farms and industries etc (WL en RIZA 2002 c; Projectgroep Spankrachtstudie 2002 c). All these effects were assembled in a large database, the basis of the Planning Kit (WL & RIZA 2002 e).

DSS THE PLANNING KIT

Basically the Planning Kit is a database which can be operated by a graphic user interface. In the database several kinds of effects of the evaluated measures are collected such as reductions of waterlevels, costs, gain of nature, number of houses to be removed etc. In the user interface measures are selected. This user interface immediately shows the combined effect of the selected measures on the design flood levels in a graph, simply using the principle of superposition.

To enable a convenient operation, in the Planning Kit the branches of Rhine and Meuse are subdivided into 10 sections. This subdivision is based upon the characteristics of the distinguished sections.

Figure 3 shows a scheme of the sections. This scheme pops up when the button 'map' in the middle of the Planning Kit screen is clicked (see Fig. 4). In this map a section can be selected for which a set measures is to be evaluated.

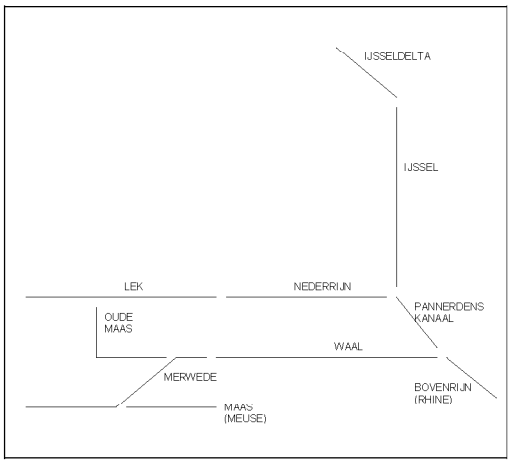

Fig. 3 Scheme of sections of the branches of Rhine and Meuse in the Planning Kit.

When a section is selected, for instance the section 'Waal', the Planning Kit shows a screen with information about this section. This screen is subdivided into two parts. The upper part of the screen shows the names and individual effects of the available measures. Also in the left columns with marks is indicated whether an aerial photograph is available (binocular) or site photo's are available (camera). By clicking the binocular or camera the available photos pop up.

The lower part of the screen shows in a graph the combined hydraulic effect of selected measures in relation to the hydraulic task on the section. This hydraulic task is the raise of the design flood levels due to a selected increase of the river discharge.

The showed screen dump in Fig. 4 illustrates this for the section 'Waal'. This section lies roughly between the cities of Nijmegen and Gorinchem. It is possible to select measures as well in the upper part of the screen as well in the lower part. In the upper part the name of a measure should be clicked, in the lower part the green mark corresponding with a measure may also be clicked. The screen dump shows

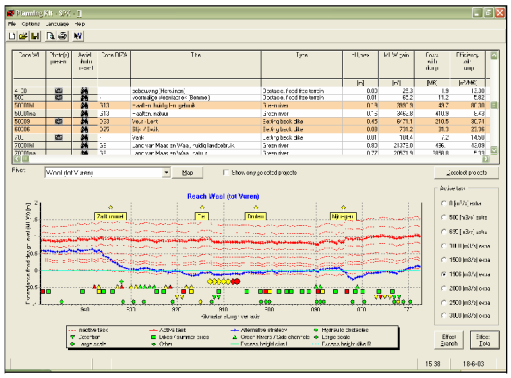

Fig. 4 Screen dump of the section Waal

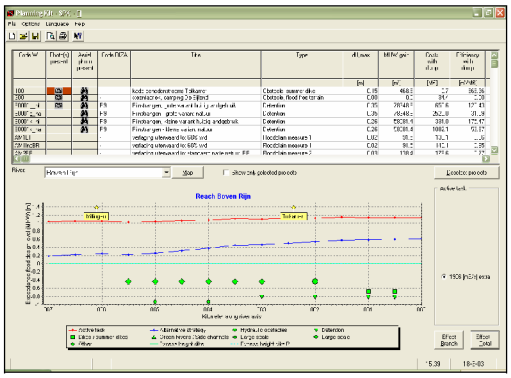

Fig. 5 Screen dump of the section Bovenrijn.

that selected measures are high lighted in the upper part of the screen and in the lower part the corresponding green marks are turned to red. Also the screen shows which potential measures are excluded for further selection by the already selected measures because the green marks in the lower part of the screen are turned yellow. The yellow marks indicate for instance alternatives of already selected measures or different measures but on the very same spot. In the selection of measures the Planning Kit offers a powerful option: Measures can be arranged on the magnitude of a certain effect. For example measures can be arranged on their hydraulic effects (high values preferred), costs (low values preferred), cost effectiveness (high values preferred), amount of polluted soil (low values preferred) etc. This helps to assemble sets of measures from a specific point of view.

The effects of the measures as shown in the lower part need more explanation. On the right hand side, next to the graph, there is a list of discharges. These discharges represent possible rises of the design flood discharge. These possible rises may depend on the scenario of climate change or on desired changes in the subdivision of the discharge of the Rhine over its branches Waal, Nederrijn and IJssel.

When a rise of the design discharge is selected, the graph will show a corresponding rise of the design flood level (the bold red line). Figure 4 shows that when the discharge over the branch Waal increases with 1906 m^3/s, that the design flood level will rise with about 80 – 100 cm.

The purpose of taking spatial measures is that the effect of the extra discharge on the design flood level is compensated. The difference between the bold blue line and the bold red line indicates the cumulated effect of the selected measures. Sufficient measures are taken when the bold bleu line is lowered under the 0-line.

The Planning Kit takes into account that measures might have upstream or downstream effects in other sections than the section along which measures are selected. For instance: a large dike relocation near the upstream end of the section 'Waal' also causes a fall of the water level on the upstream section 'Bovenrijn'. When the screen is switched to 'Bovenrijn' this is visible in the graph: without any selection of measures along 'Bovenrijn' itself there is already a significant difference between the bold red en blue lines, as can be seen in Fig. 5.

On the other hand when along the section 'Bovenrijn' a detention measure would have been selected, it would have caused a fall of the water level along the downstream section 'Waal'.

After assembling a set of measures a report of the effects of this set can be printed by clicking the button 'effect branch' or 'effect total'. Since there is quite an amount of effects evaluated by the Planning Kit these reports are rather extensive (about 2 pages for one section and about 10 pages for all river branches). Therefore this article does not present an example of such a report.

It should be noted that the Planning Kit assumes linear superposition of the hydraulic effects of the individual measures in a set measures. Theoretically this assumption is not completely correct. However, recalculation of complete sets of measures with the calibrated hydraulic model shows that the error of superposition is rather small. Overall the error is less than 10% and in most of the cases the hydraulic

effects of sets of measures are rather slightly underestimated than overestimated (WL en RIZA 2002 e). Therefore the Planning Kit is considered a reliable instrument for policy analysis purposes.

For design purposes, however, recalculation of complete sets of measures with a calibrated hydraulic model is of course required. Also should be mentioned the Planning Kit is not completely fool proof; some hydraulic knowledge of the users is supposed when composing consistent and feasible sets of measures.

APPLICATION OF THE DSS PLANNING KIT IN THE SPANKRACHT STUDY

In the Spankracht study the Planning Kit has been intensively used for the evaluation of what feasible options to solve the long term safety problem could come forward out of the three hundred available measures (Projectgroep Spankrachtstudie 2000a). Mainly two types of analyses were carried out. The first type of analysis focused on the effects of the different types of measures along the branches as a whole, for instance:

- How much can the discharge capacity be enlarged by applying excavation of floodplains along the branch as a whole, with or without saving existing values like ecological and cultural values in these areas?
- How much can the discharge capacity be enlarged by applying all the measures available within the riverbed?
- How much can the discharge capacity be enlarged by the inland relocations of dikes?
- How much can the discharge capacity be enlarged by the green rivers?
- How much ca the discharge peak be reduced by using detention?

The other type of analyses focused on the evaluation of desires of the parties concerned. This resulted into three sets of measures that solve the long term problem from specific points of view:

- A set of measures that solves the problem against the lowest costs (Fig. 6).
- A set of measures that focuses on as must as possible detention, and as least as possible enlargement of the discharge capacity along the river branches.
- A set of measures that as much as possible contributes to the spatial qualities (landscape, ecology, cultural history, options for economical development) of the Rhine and Meuse district.

In these analyses the actual assembling of a set of measures doesn't take more than a quarter of an hour and an adaptation to new insights or desires is made in a flash. Therefore all efforts can be focused on discussing the concerned interests and qualities that are aimed for. During the Spankracht study the Planning Kit proofed well applicable as a tool in collaborative planning sessions.

MAJOR CONCLUSIONS OF THE SPANKRACHT STUDY

In the Spankracht study a huge number of measures (and a corresponding number of measure sets) had to be evaluated. Never the less the Spankracht study came to conclusions within about a year, due to intensively using the Planning Kit (Projectgroep Spankrachtstudie 2000a).

Major conclusions of the Spankracht study include (Projectgroep Spankrachtstudie 2000a):

- A change of strategy from enlarging the dikes to returning room to the river system offers opportunities to develop new spatial qualities in the river district. Measures within the existing riverbed offer opportunities to enlarge spatial qualities in the floodplain while large scale inland measures offer opportunities to enlarge the spatial quality in the inland areas. However, these opportunities are only cashed when attention is paid to the design of the measures.
- Spatial measures are therefore from a socio-economical point of view not necessarily much more expansive than the enlargement of the dikes. Although the direct project costs may be higher, there are considerable socio-economical benefits to compensate the direct project costs.
- For the short term, measures in the existing floodplain may be sufficient to allow enough enlargement of the discharge capacity while existing values can be saved. On the long run, however, large scale inland measures can not be avoided, in case the climate change develops according to the present knowledge. In the densely populated Netherlands this requires radical decisions.

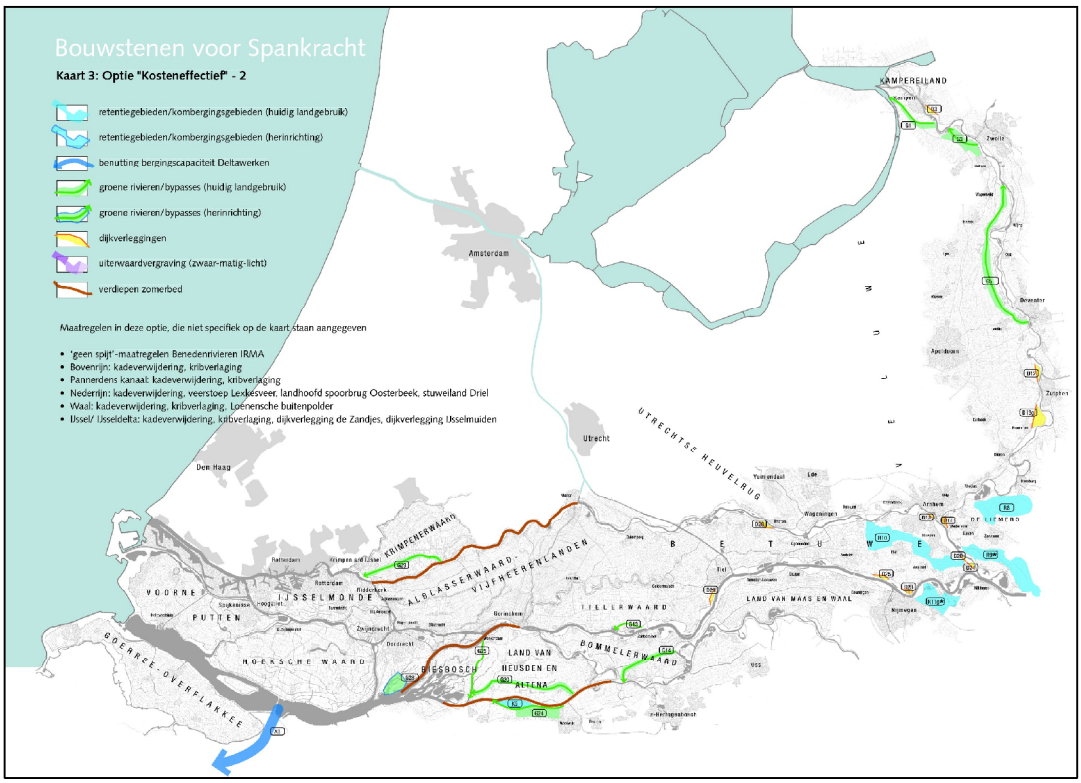

Fig. 6 Map of the set of measures according to the lowest costs

- Along the Rhine branch Nederrijn and Lek for the short term there are enough options to enlarge the discharge capacity. On the long run the options to enlarge the discharge capacity are not to good, especially on the section Lek. Therefore a redistribution of the discharge over the Rhine branches is recommended: The branches Waal and IJssel should take more than their equal share, which is possible taking the options into account along these branches. Such a redistribution of the discharge is mainly established by carrying out spatial measures along Waal and IJssel and by doing so lowering the relative resistance of these branches.
- Detention around the upstream bifurcation points of the Dutch Rhine branches is likely to be a very cost-effective option. Half of the long term problem may be solved by applying 4 detention areas. On the other hand, these measures are from a social point of view very drastic.

CONTINUATION AND DECISIONS

The Spankracht study is a policy analysis which aimed for insight in the long term safety problem and options to encounter this problem. Decisions have not been taken yet.

At this moment a policy analysis is carried out for the safety problem on the short term (2015). In this short term study a new and more detailed version of the Planning Kit is used in collaborate planning sessions to establish effective and accepted sets of measures. These sets of measures are evaluated in an environmental impact assessment. In this environmental impact assessment one of the evaluation criteria is contribution of the short term solution to the long term problem. After completion of this short term policy analysis in the autumn of 2004 first decisions will be taken on short term measures and on spatial reservations for on the long run essential large scale inland measures.

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