

THE MIND IN THE MODEL: CAPTURING EXPERT KNOWLEDGE WITH THE HELP OF FUZZY LOGIC

J. A. E. B. Janssen¹ & R. M. J. Schielen^{1,2}

¹ Water engineering and management group, faculty of CTW, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands; j.a.e.b.janssen@utwente.nl

² Rijkswaterstaat RIZA, PO Box 9072, 6800 ED Arnhem, The Netherlands

Abstract

Fuzzy logic offers a way of capturing qualitative knowledge in models. We tested its application in modelling for long term river management planning. We used fuzzy logic to model landscape impacts of different river measures. Preliminary results show that the method allows for modeling expert knowledge concerning landscape effects. The resulting model is rapid and transparent. However, the elicitation of the –often ambiguous- expert knowledge remains one of the major concerns.

Introduction

River management involves a lot of qualitative knowledge. Dealing with qualitative knowledge has the disadvantages that 1) the qualitative information is not always reproducible and that 2) a high dependency on the experts remains existent throughout the planning process. Previous work [De Kok, 2000] suggests using fuzzy logic as a tool for capturing expert knowledge, in this way improving model performance. The expert knowledge we used is extracted from the Integrale Verkenning Maas -1 (IVM-1) project. IVM-1 is an integrated explorative study of measures proposed for improvement of flood safety along the Maas in the Netherlands. One of the effects assessed in the IVM-1 study is the effect on space and landscape [Ministerie van Verkeer en Waterstaat, 2002]. The background report on space and landscape, containing the outcomes of expert studies, forms the basis for our fuzzy model.

Method

We will implement the expert knowledge from the IVM-1 project in a fuzzy model to assess the effect on landscape of ten different measure types on eight river stretches in the Dutch Maas. According to the background study on space and landscape a combination of landscape and measure characteristics determines the eventual effect on landscape. With a selection of these we obtained the conceptual model shown in Figure 1. Where possible, both landscape and measure characteristics are represented as fuzzy inputs. The next step was to implement the variables into the Matlab Fuzzy Toolbox ®. Nguyen (2005) has shown that the outcomes of the fuzzy model have a low sensitivity to the shape of membership functions (MF's), so we opted for the relatively simple triangular MF's, implemented in a Mamdani inference system.

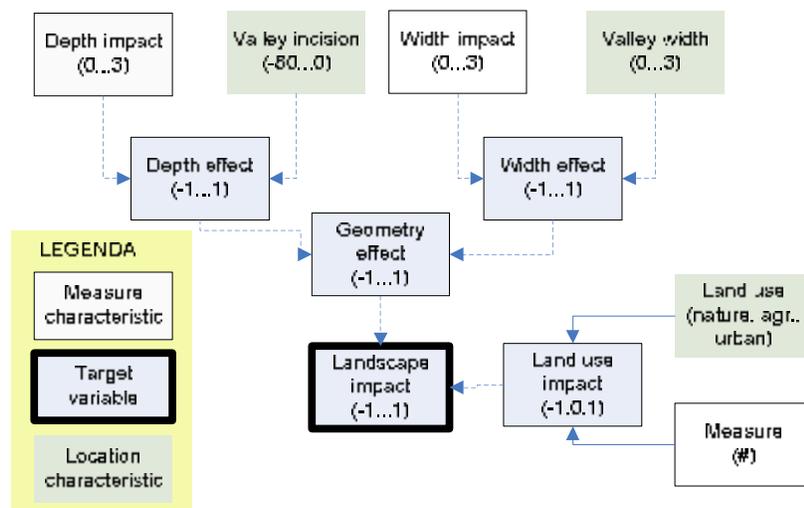


Figure 1: Conceptual model; fuzzy relations are dashed

Results

In the IVM-1 background report measures, or some of their characteristics, are linked to the landscape: 'The relative high elevation level of the environment of the undiked Maas leads to limited opportunities for (the creation of) green rivers'. Features like incision, valley width, and land use return for every river stretch as determinative elements for landscape quality. In combination with the measure characteristics that affect these, they form the inputs for the model. The land use and land

use impact could not be modelled fuzzy because the variables cannot be scaled on a continuous range. In Figure 1 the fuzzy model relations are indicated in dashed lines. Running this model gives a score for every measure type on every river stretch. Originally these were defuzzified by Matlab, but for the sake of a suitable uncertainty representation they are translated back into the fuzzy output categories [Janssen, 2006]. The result is shown in Table 1. The shaded cells give the models' outputs for cells that also have an IVM-1 score (given in coloured plus, zero and minus). Non-shaded cells indicate model outcomes where no value is given in the IVM-1 study.

Table 1: Outcomes of fuzzy model and IVM-1

	RIVER STRETCH							
	Bovenmaas	Grensmaas	Plassenmaas	Peelhorstmaas	Z. venlostenk	N. venlostenk	Benedenmaas	Getijdenmaas
+ = enforcing measure (IVM-1)								
0 = neutral measure (IVM-1)								
-- = deteriorating measure (IVM-1)								
+ , 0 , - = score in fuzzy model								
MEASURE TYPE								
Retention	-	0	+	0	0	+	0	0
Lowering river bed	0	0	+	0	0	+	+	+
Widening river bed	0	+	+	0	0	+	+	+
Remove obstacles	-	+	-	-	-	+	-	-
Lowering floodplain	-	-	-	-	-	+	+	+
Lowering bank	+	+	+	+	-	-	+	+
Widening bank / floodplain	-	+	+	+	-	+	-	+
Relocate dyke	0	+	+	+	-	+	+	+
Green river	0	+	+	+	0	+	+	0
Quay relocation	+	0	+	+	+	+	-	+
Flood channels	-	+	+	+	-	+	-	+

Conclusions

The results are fairly resembling the IVM-1 results. Differences may be caused because not all relevant characteristics of both measures and location (stretch) are taken into account. The speed of calculation, which is only a few seconds, and the relative transparency of the method however make further research promising. One of the most important steps in future research will be to optimize the expert knowledge elicitation.

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