Fuzziness to Reduce Uncertainty

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INTRODUCTION

In the Netherlands space is a valuable asset. Sometimes new locations have to be found for an certain function in an certain area, but the area is claimed already completely by other functions that exclude the new function. An example is the case study that was carried out in the GeO3 project. The case study was initiated by the Dutch ministry of Agriculture and the Dutch Cadastre and dealt with finding a location for cultivation under glass within certain area in the Netherlands. The area is claimed by rural plans of the municipalities and by zones of the Natura2000 areas and the ecological main structure and leaves hardly any space for a large area of cultivation under glass. These three-km-zones around Natura2000 areas and ecological main structures are in fact continuous objects that are discretely defined (often by law). Although the zones concern mainly ammonia emissions, it is generally interpreted as ‘not to be used for all agrarian activities’. However, cultivation under glass is not a agrarian activities that emits amounts of ammonia compared to intensive pig farming. One of the main environmental influences that is caused by cultivation under glass is sound. Sound is a very different environmental factor than ammonia emission and for that reason it should be treated differently.

This situation causes uncertainty. One knows that one is legally bounded by the 3-km zoning, but one also knows that the reason behind the zoning (ammonia emission) is not an issue for the function cultivation under glass. For this reason this situation was dealt with as a case study in the GeO3 project. The objective of the GeO3 project was to study various characteristics of uncertainty in spatial planning, to define them and to suggest solutions to deal with them. The project resulted in a taxonomy for uncertainty in spatial planning (Vullings et al. 2007). One of the sources of uncertainty is objects that are continuous phenomena (noise, emission, risk, zones etc.), but are treated like discrete objects. A solution for dealing with this kind of uncertainty could be to use the fuzzy set theory.

The objective of this case study was to research whether fuzzy logic could be used to deal with continuous phenomena that are generally represented as discrete objects and whether using fuzzy logic would result in more space for the location of cultivation under glass than with the conventional discrete analyses.

FUZZY SET THEORY

The concept of fuzzy logic was introduced in 1965 by Zadeh (Zadeh, 1965) as an extension to Boolean logic. The principal of Boolean logic is that something is true (1) or false (0). This idea is abandoned in fuzzy logic; because in fuzzy logic something can also be partly true and partly false. Therefore an object can be part of an object class (1) or not (0), but it can also be partly a member of this object class (every value between 0 and 1).

Figure 1: Transition areas based on crisp buffer (left) and on fuzzy buffers (right).

The rate at which a fuzzy object participates in an object class is called the membership of this object to the object class. Duindam concluded that it is preferred to determine a new membership function for modeling fuzzy objects in spatial planning: Planning Object Membership function (POM) (Duindam 2006).

For this case study a POM demonstrator was realized. The POM demonstrator is an extension of ArcGIS and is able to generate, visualize and analyze fuzzy objects. As main factor for finding suitable locations is chosen for noise hindrance for nature areas and housing locations caused by traffic of products and basics to and from cultivation under glass. To generate fuzzy zones the parameters of the POM function for the influence of sound had to be set. After generating the fuzzy zones the zones were divided into three classes with different policy implications. Both setting the parameters and defining the classes was done by experts.

Figure 2 shows that a larger area is available as placement area with the fuzzy method than with the conventional method .

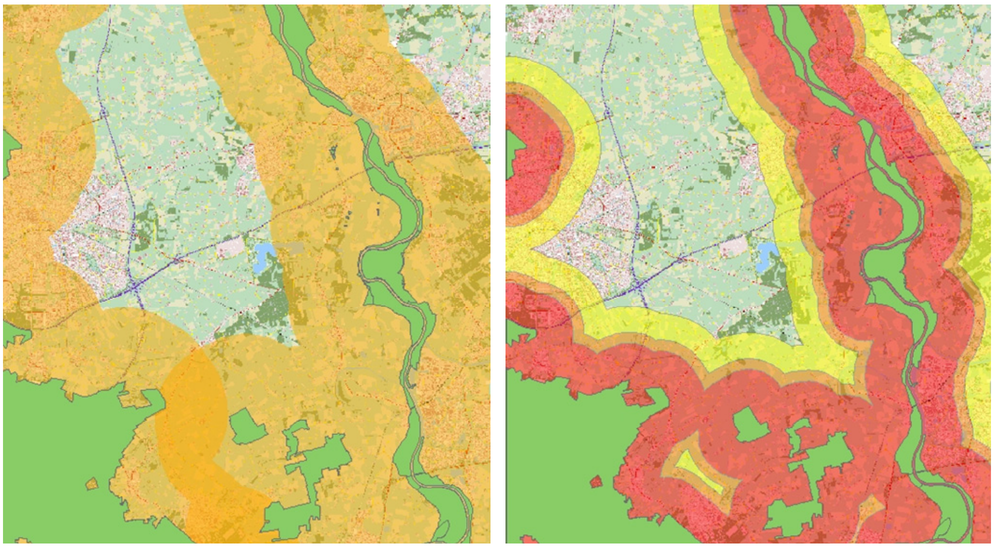

Figure 2: Left: Natura2000 areas with a discrete buffer of 3 km. Right Natura2000 areas with a red zone (no cultivation under glass), orange zone (No cultivation under glass, unless…), yellow zone (cultivation under glass possible, if…).

CONCLUDING REMARKS

The case study showed that this method leads to finding more space for placement of cultivation under glass within the study area. However the case study also showed that dealing with environmental factors like noise in a quantitative way asks for a different approach within spatial planning. To set the parameters of the POM function and to classify the zones was not easy, not even for the experts. Normally environmental factors are dealt with in a more intuitive way, to valorize these relationships is new and scary. The advantage of the use of the POM demonstrator is that it showed the implications of choices on the fly, which lead to useful discussions and decisions about environmental relationships. Another aspect is that the fuzzification of the Natura2000 zones is legally not possible yet, but this case was used to proof the usefulness of the method. The participants of the case study thought the method has potential, they were interested in this different approach and liked to pursue further development.

BIBLIOGRAPHY

Duindam, A.J., 2006. Fuzziness in spatial planning data – an exploration in uncertainty. Centre for geo-information, WUR. Research report GIRS-2006-20

Fisher, P., A. Comber and R. Wadsworth (2005). Approaches to Uncertainty in Spatial Data. Pp. 9-64 in Qualité de l'information géographique, (eds. Rodolphe Devillers and Robert Jeansoulin), IGAT, Hermes, France

Vullings, W., M. de Vries, et al., 2007, Dealing with uncertainty in spatial planning. 10th AGILE International Conference on Geographic Information Science. Aalborg University, Denmark.

Zadeh, L. A., 1965. Fuzzy sets. Information and Control 8(3): 338-353.