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# FIG WORKING WEEK 2023

28 May - 1 June 2023 Orlando Florida USA

Protecting  
Our World,  
Conquering  
New Frontiers

## Combining GIS with Fuzzy Logic and Scenario Planning to Deal with Demographic Change

### A Case Study on Medical Supply in Rural Germany

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## Agenda

- Setting the Frame: Why bother?
- Methodology: Data, Scenario Analysis, Fuzzy Logic
- Results: Reachability estimates in a German county
- Conclusion: Promising, but still experimental

## Setting the Frame

- Equivalent living conditions all over Germany are a state objective due to their anchoring in the German Constitution.
- Reality naturally shows significant spatial differences between metropolitan regions and rural areas, e.g. in the supply with medical facilities.

## Setting the Frame

- Health care is a core challenge for rural areas in Germany. But the increasing shortage of e.g. physicians and nurses, and the concentration of medical services in urban areas are a sign of misallocated resources[1]
- Especially in rural peripheral areas, the disproportion between relatively many elderly people and relatively few specialized medical facilities is pronounced

## Setting the Frame

- Geoinformatics can make a good contribution here and has been does so through accessibility analyses

*Answering questions like: "How far is it to the doctor? How long does it take? Are medical offices appropriately distributed with regard to population size and structure?"*

## Setting the Frame

- However, the existing inequality in Germany has been increasing. This has many reasons. You cannot blame our profession (GIScience) for that in the first hand, but
- There is also room for improvement in spatial analyses, supporting decisions on medical supply facilities.

## Setting the Frame – challenges & shortcomings

- **Data?** Accessibility analyses are often not designed for small-scale differentiation. The data needed for small-scale analyses are person-specific. Studies in Germany often avoid this challenge.
- How will the **future** be like? We do not know. But we could think more flexible/systematically about future pathways and let more people have their say in it.

## Setting the Frame – challenges & shortcomings

- **Methods?** To assess reachability, GIScience uses Shortest Path, Travelling Salesman, Location-Allocation etc.
- Combining *distance* and *age* and other parameters (like *illness* or *fitness*) would be an asset. Working without crisp thresholds seems natural „under the given conditions a senior would rather go to doctor x“. Instead of: „if it takes less than 25 min a person of > 65 years with diabetes and travelling by car goes to..."

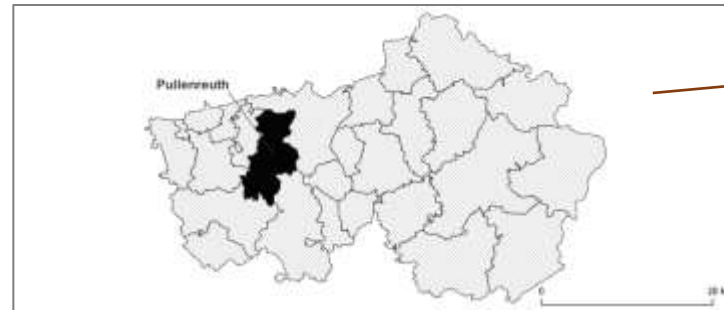


## Methodological Explanations

- Study Area

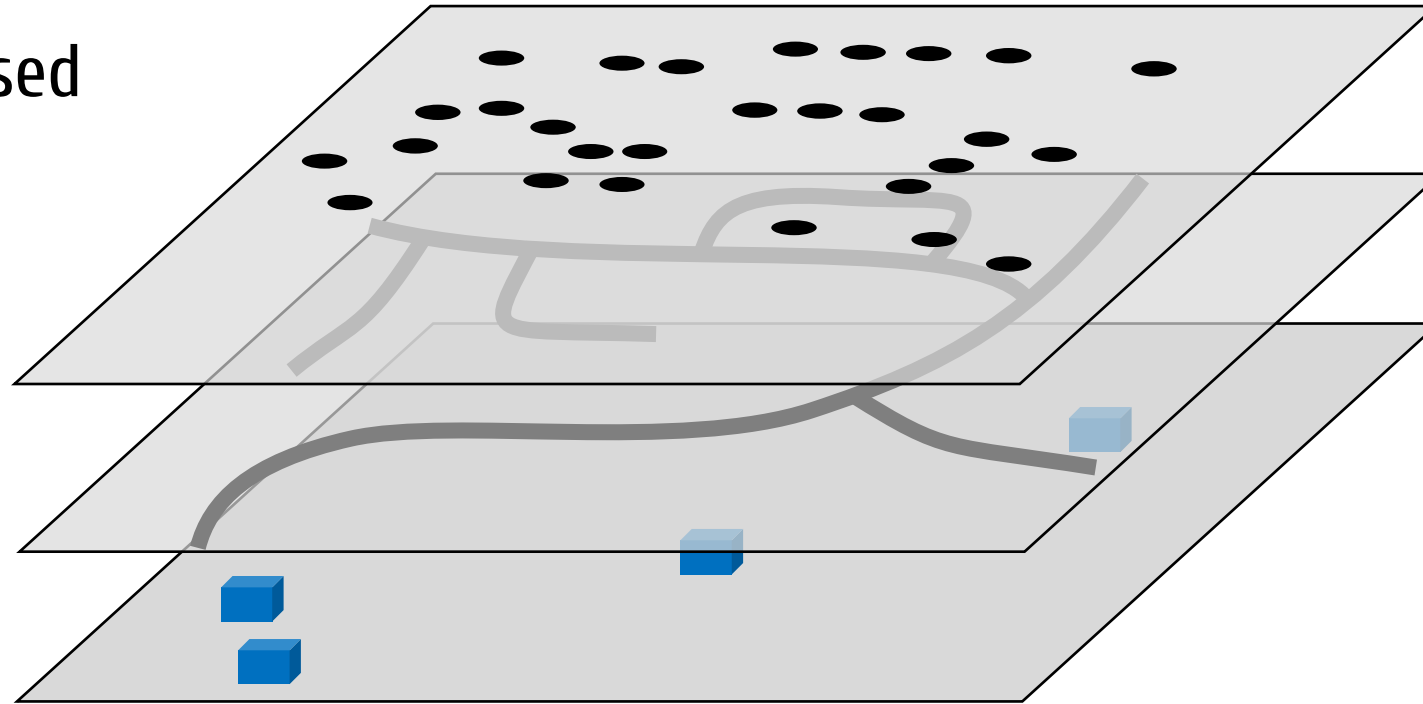
Germany →

Landkreis (county)  
of Tirschenreuth →



## Methodology

- Data we used



Population  
(address) from municipal  
population register in  
county of Tirschenreuth)

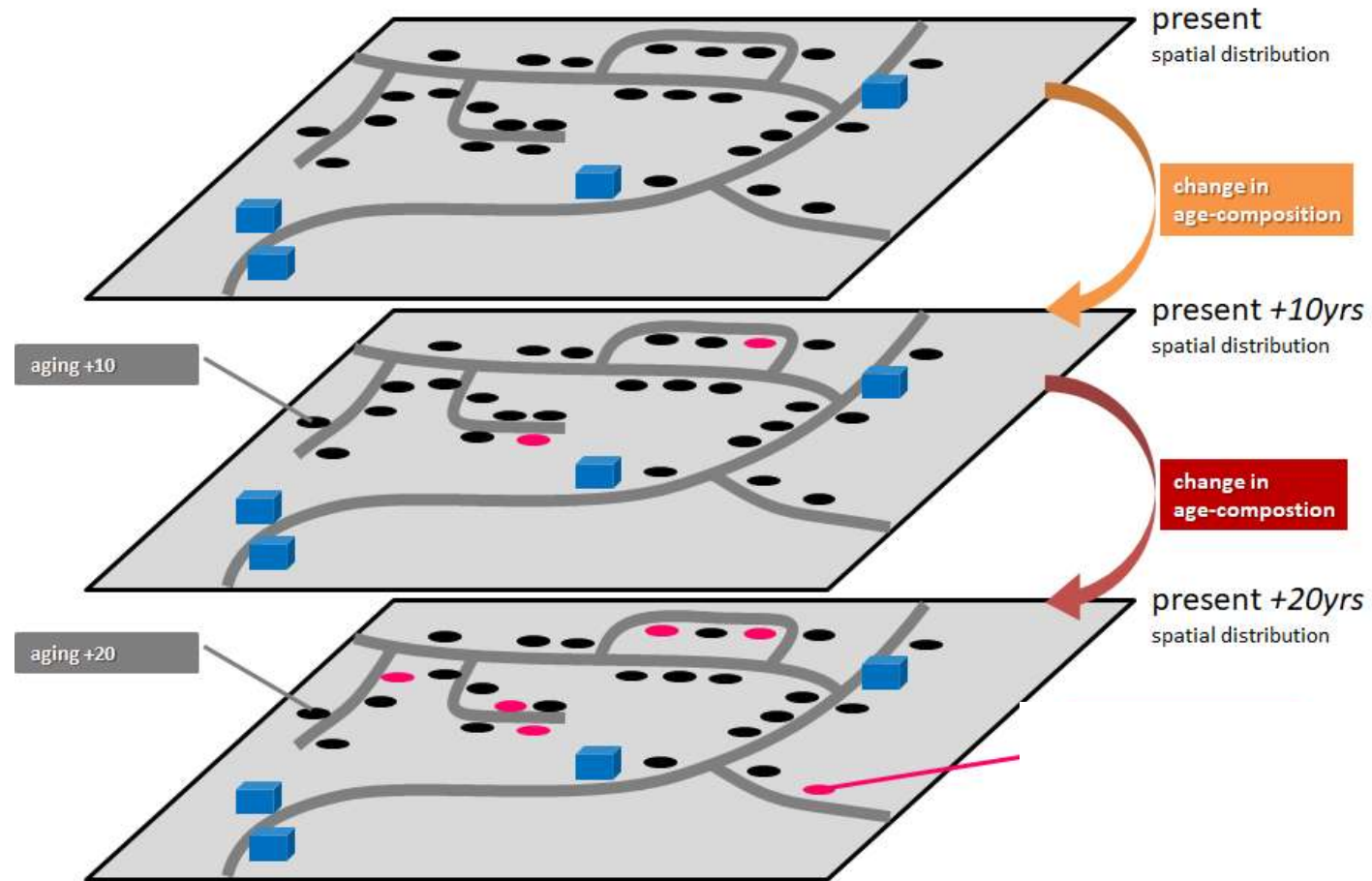
Streets  
(OpenStreetMap)

Medical facilities  
(address) from the  
Bavarian Association  
of Statutory Health  
Insurance

## Methodology

- Future age structure?

Cohort components method (for population prognosis)

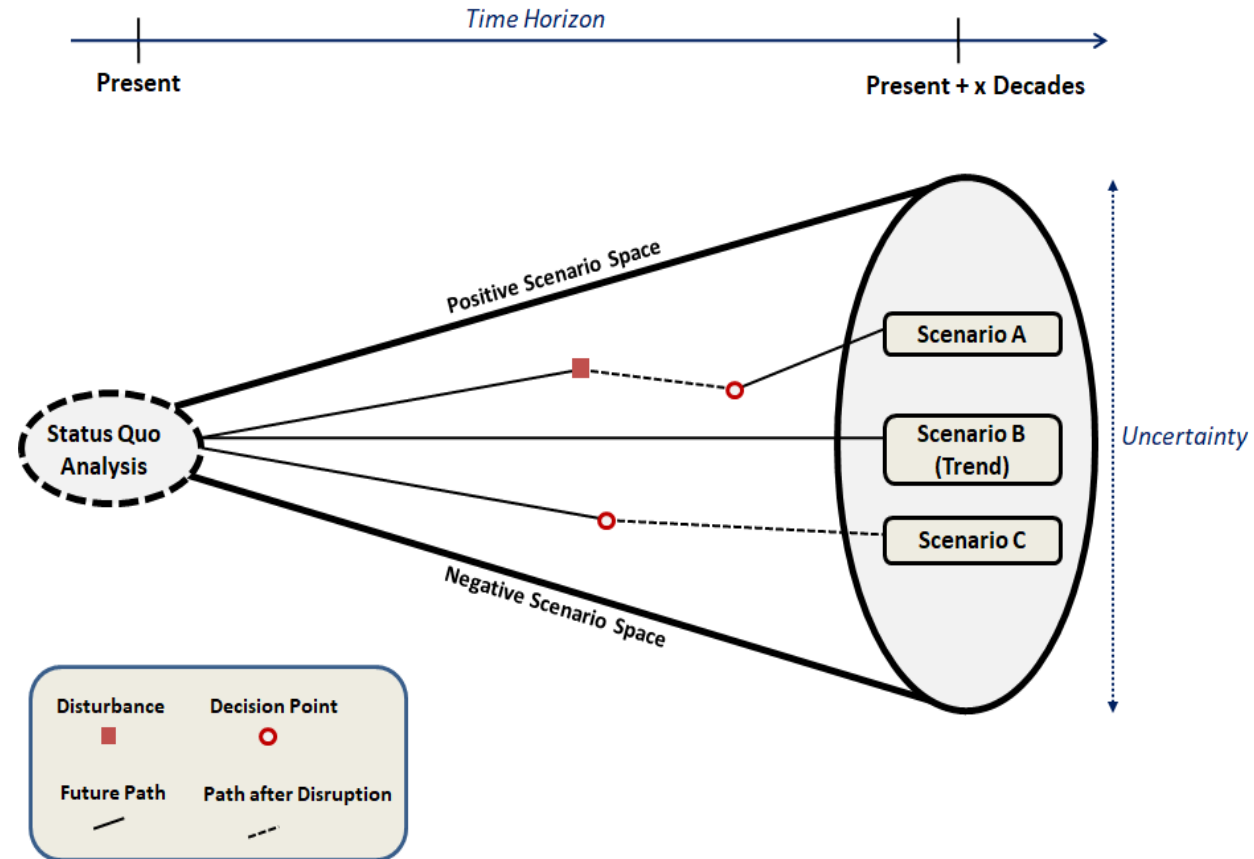


## Methodology

- Future medical facilities?

We can only calculate future location of facilities to some extent, since unknown (political) decisions are decisive

Scenario analyses (aka scenario planning/technique/method)



## Methodology

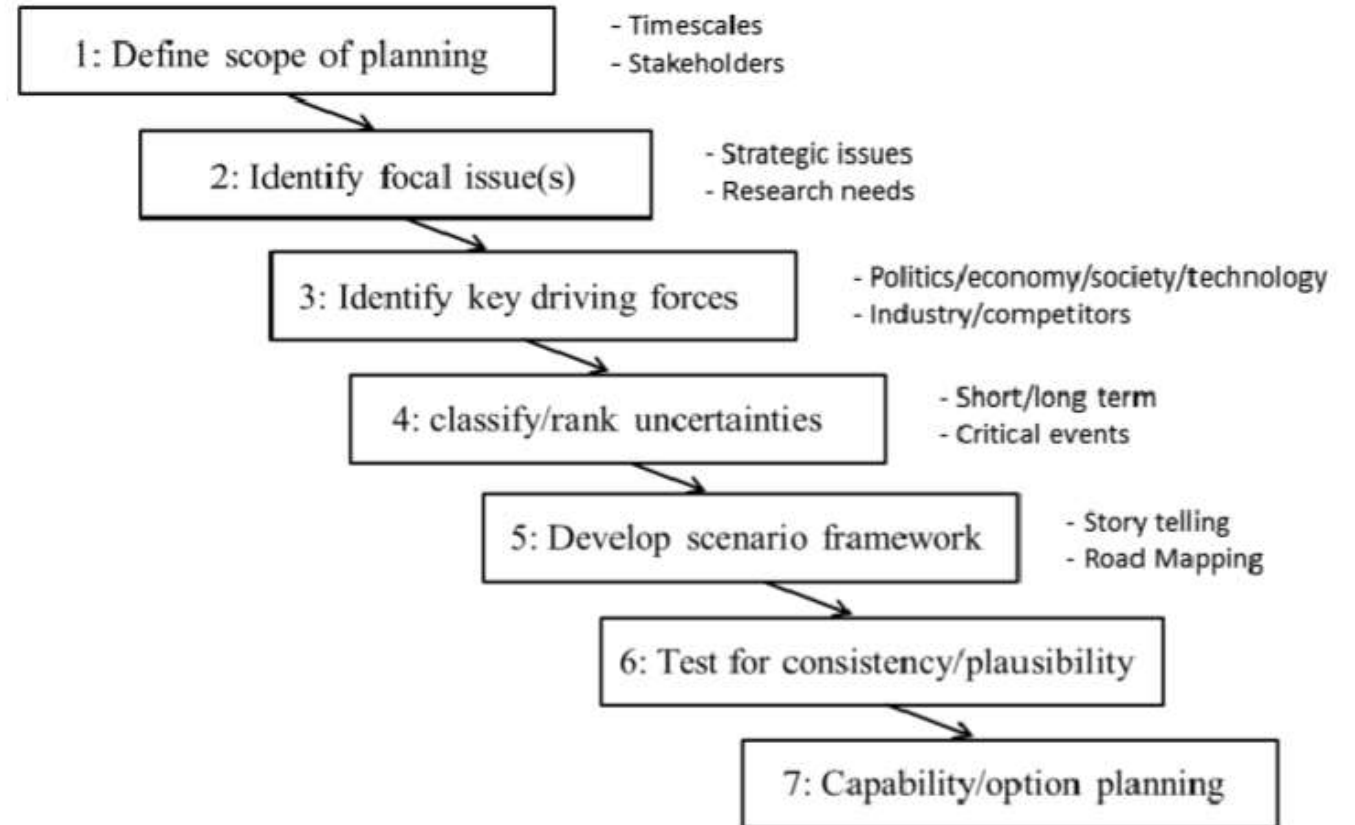
- Future medical facilities

### Scenario analyses

- De-constructs the future, qualitative approach (e.g. workshops)

*which facilities are closed in 20 years?*

*→ different options, but consistently developed*

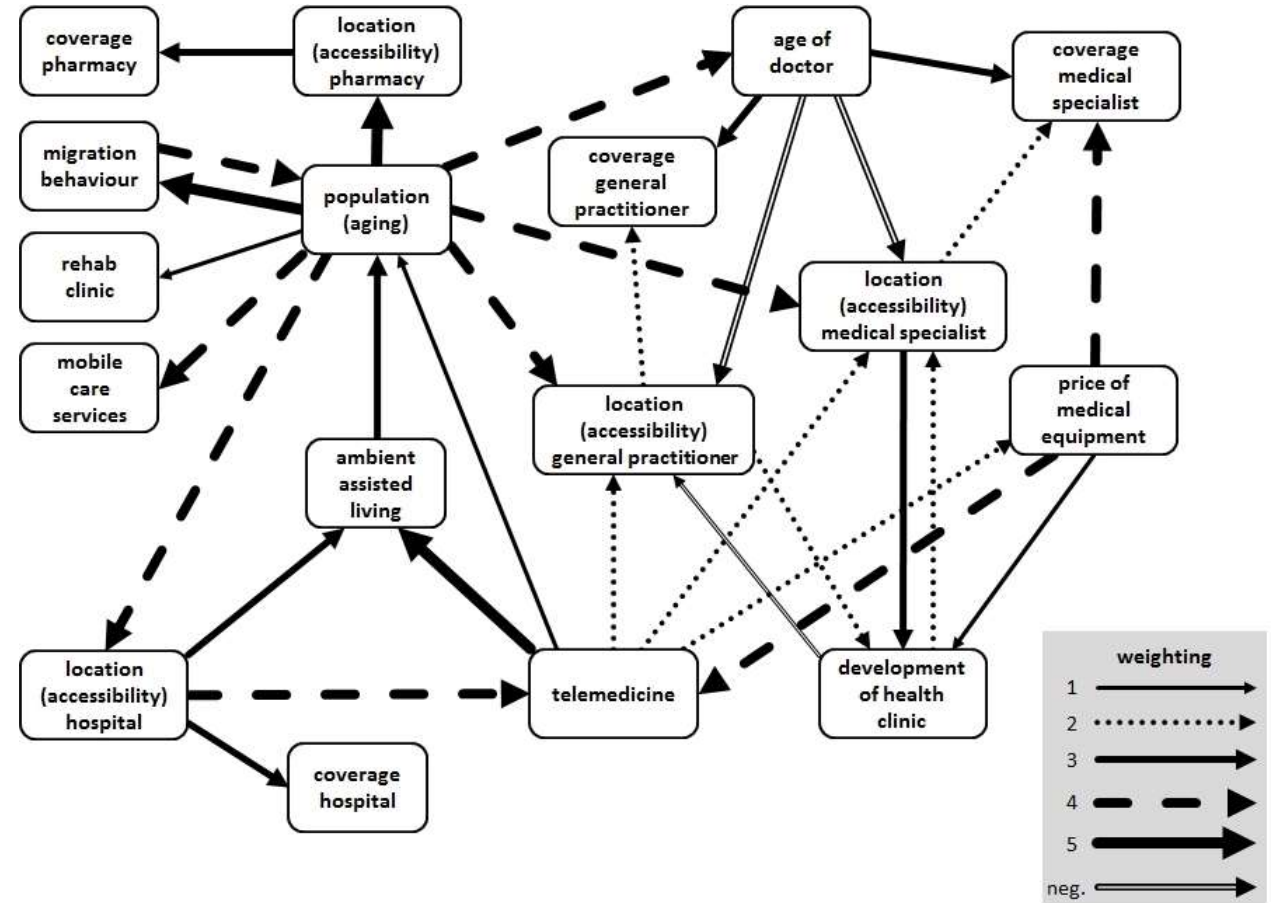


Drew S.A.W. (2006)

## Methodology

- Future medical facilities

Scenario analyses  
(aka scenario planning,  
sencario technique)



## Methodology

- Enhancing Reachability calculations with Fuzzy Logic

$$\{0, 1\} \xrightarrow{\text{fuzzy logic}} [0, 1]$$

Membership functions

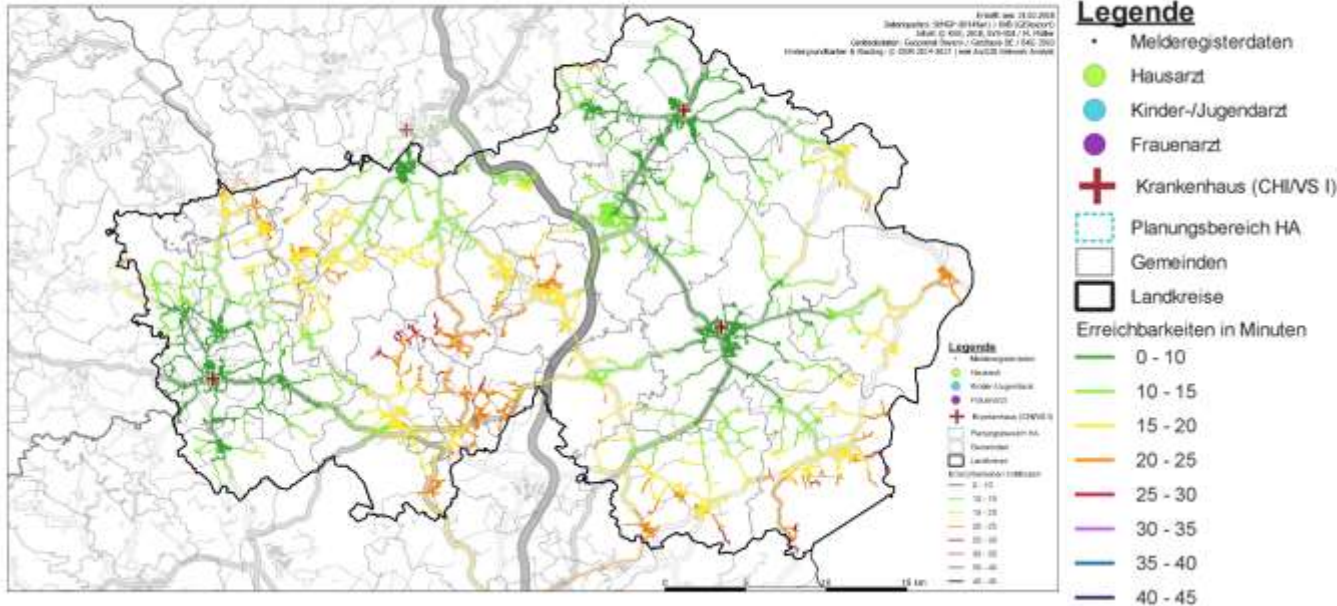


Eugster, S. (2009). The sorites paradox: If a heap is reduced by a single grain at a time, the question is: at what exact point does it cease to be considered a heap? CC BY 3.0

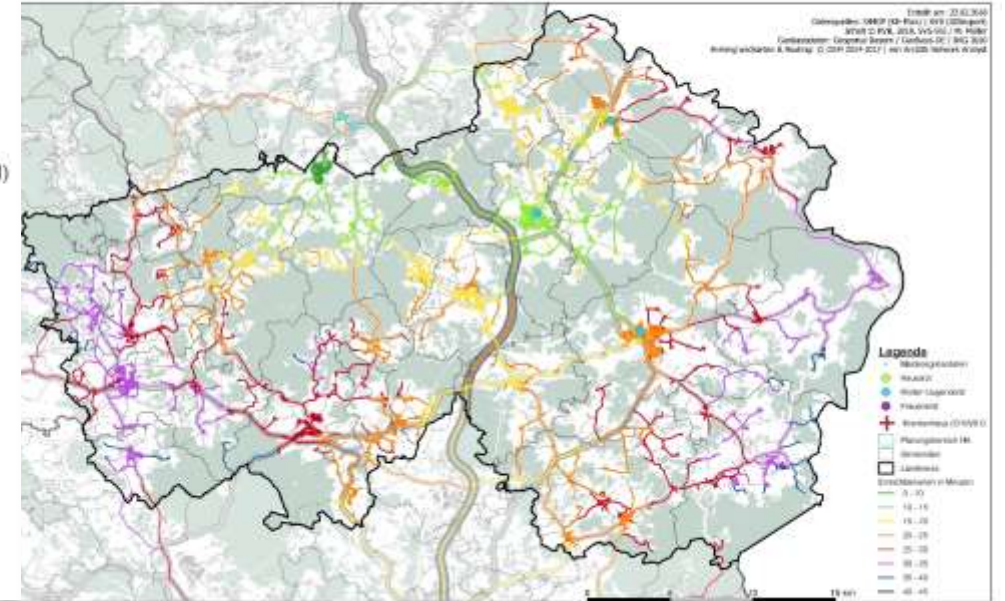
## Reachability (without F.L.)

### Results

#### Hospitals



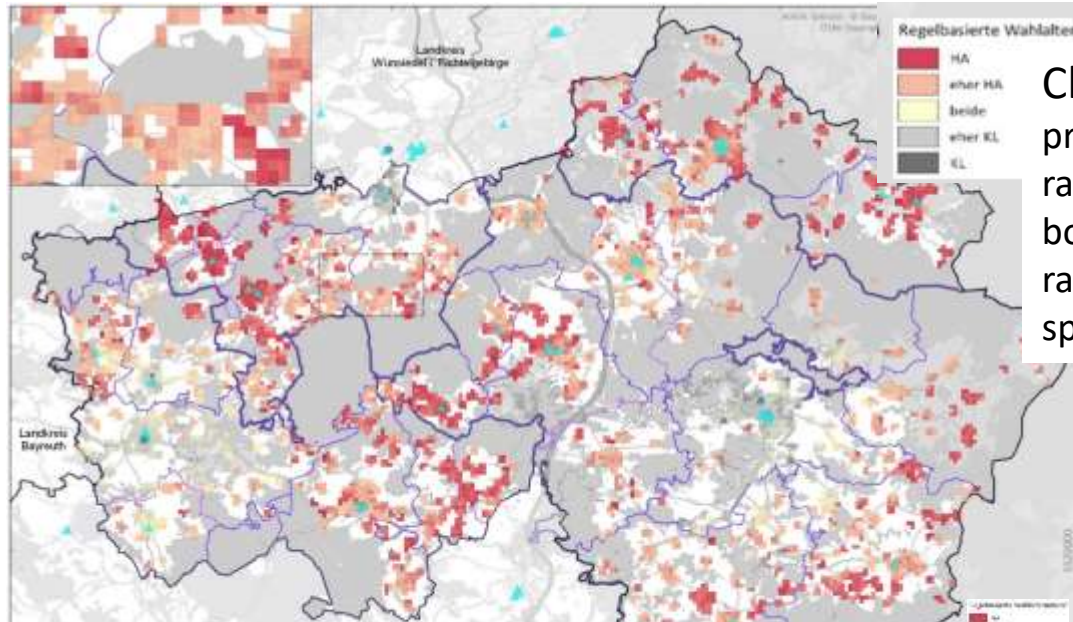
#### Practitioners (Children, adolescents)



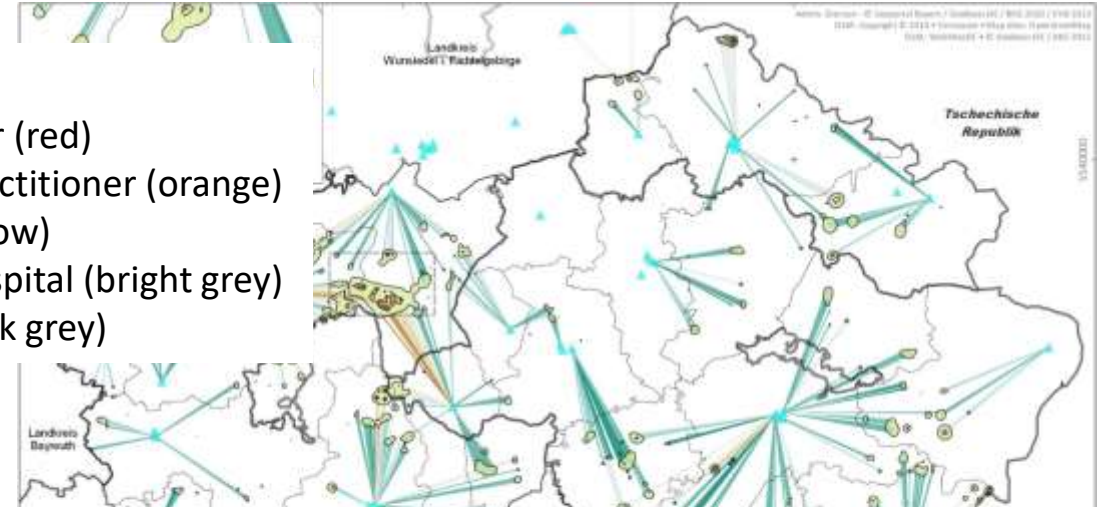


## Applying F.L.

## Results



Choice  
 practioner (red)  
 rather practitioner (orange)  
 both (yellow)  
 rather hospital (bright grey)  
 spital (dark grey)



In a final step, those regions can be identified that - depending on the question - are medically underserved, but also looking at people more individually

The data has been aggregated, but the results are however, are available for each individual person



## Conclusion

- Promising, feels right to proceed the fuzzy way
- However, it is still experimental
  - Which are the best fuzzy operators for a certain analysis? (Fuzzy logic)
  - Calculation vs. Accepting that different future scenarios are possible within a certain corridor. (Scenario analyses)

## Literature

- [1] Ruscheinski, T. (2023). Herausforderungen ländlicher Räume–das Ziel gleichwertiger Lebensverhältnisse. In Smart Region: Angewandte digitale Lösungen für den ländlichen Raum: Best Practices aus den Modellprojekten „Digitales Dorf Bayern “ (pp. 9-23). Wiesbaden: Springer Fachmedien Wiesbaden
- (2) Drew, S. A. (2006). Building technology foresight: using scenarios to embrace innovation. European Journal of Innovation Management, 9(3), 241-257.

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