Processing imperfect information in empirical research: Theory and application of fuzzy logic methodology

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Structure of talk

1. Fuzzy logic – a motivation
2. Methodology
   - ➤ Architecture of a Fuzzy Inference System
   - ➤ Key ideas of fuzzy logic
3. Application
   - ➤ Theory
   - ➤ Model
   - ➤ Results
4. Conclusions

1. Fuzzy logic – a motivation

- ➢ How to assess a person's size?
  - – tallness
  - – weight
  - – dress size
- ➢ Precise measurement unfeasible
- ➢ Correctness of answers questionable
- ➢ Interpretation of concepts different
- ➢ Fuzzy logic = common way of thinking

1. Fuzzy logic – a motivation

➢ Problems in econometrics:

- – Complexity of systems
- – Imprecision of quantitative data
- – Only qualitative data available
- – Strong assumption on the quantitative relations
- – Outliers
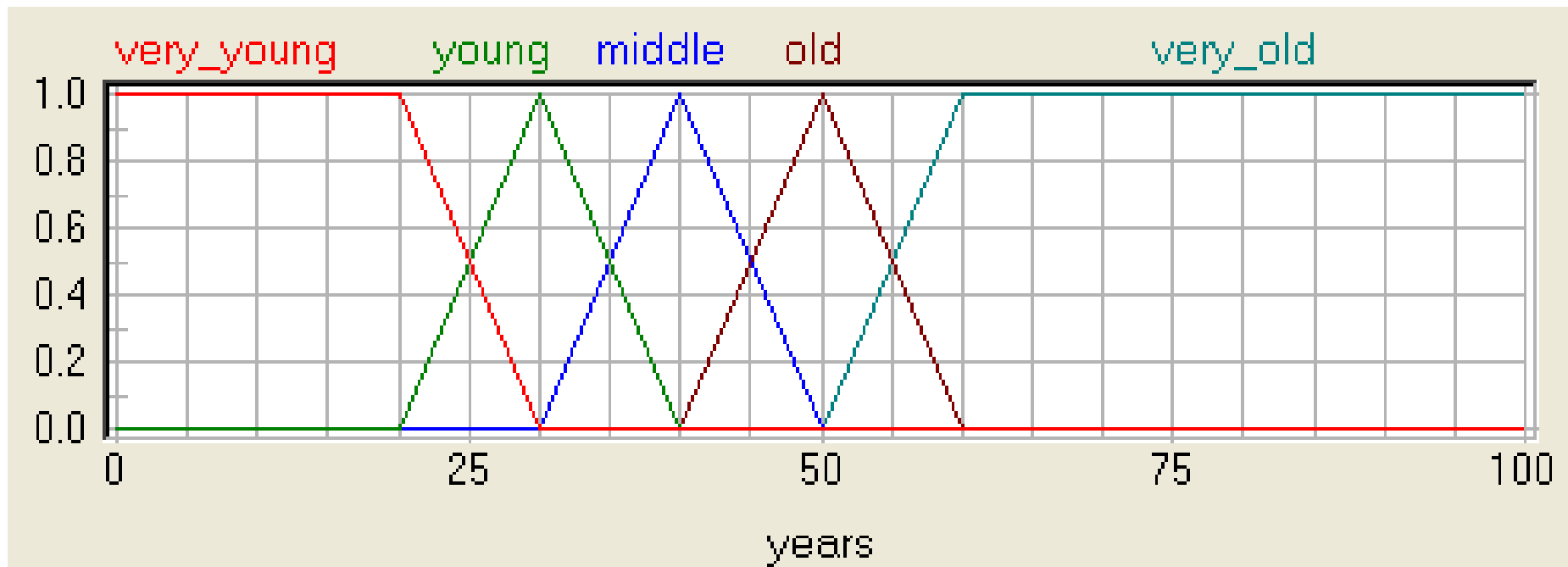- – No quantitative relation known but qualitative statements possible

Architecture of a Fuzzy Inference System
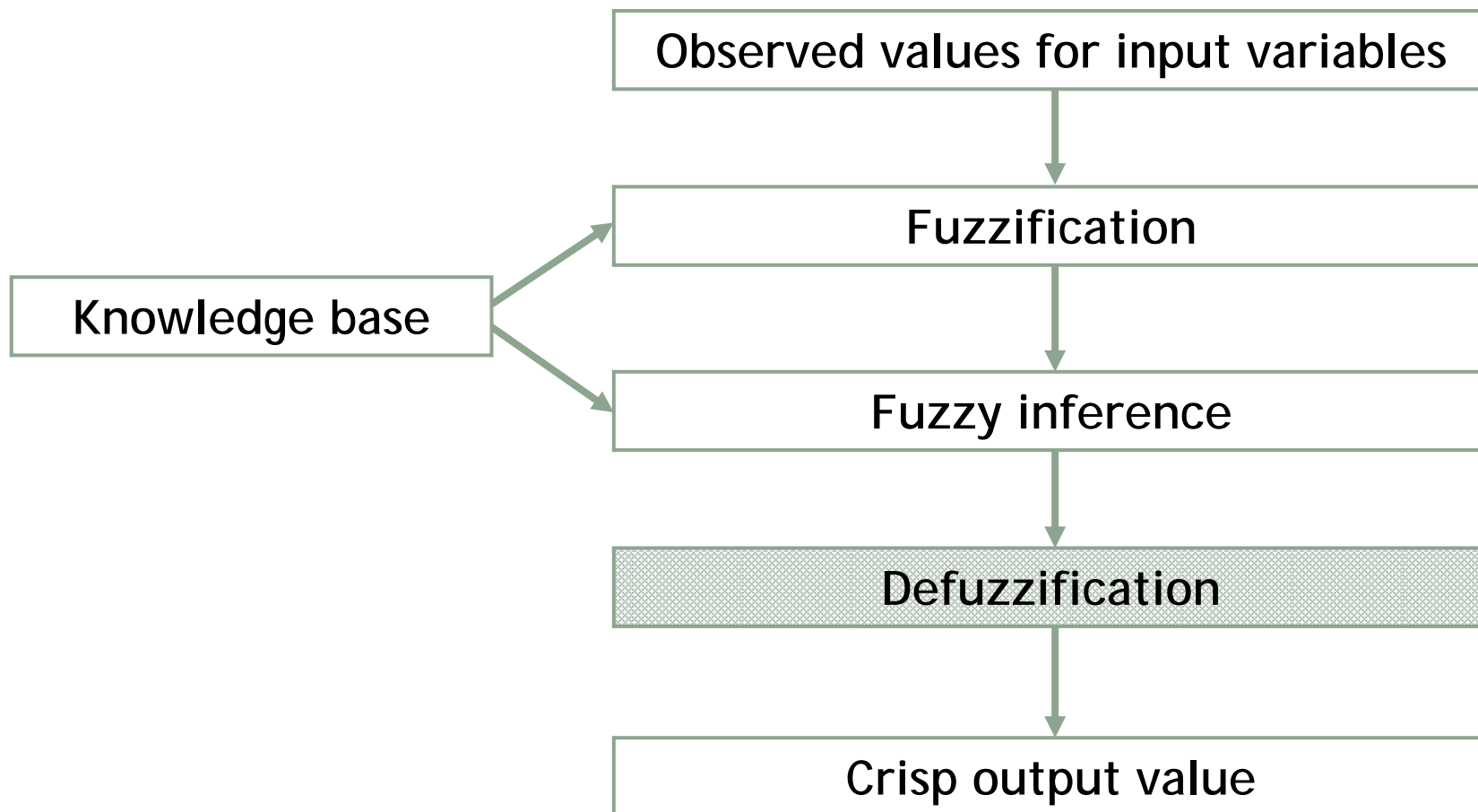
Key ideas of fuzzy logic - fuzzy value
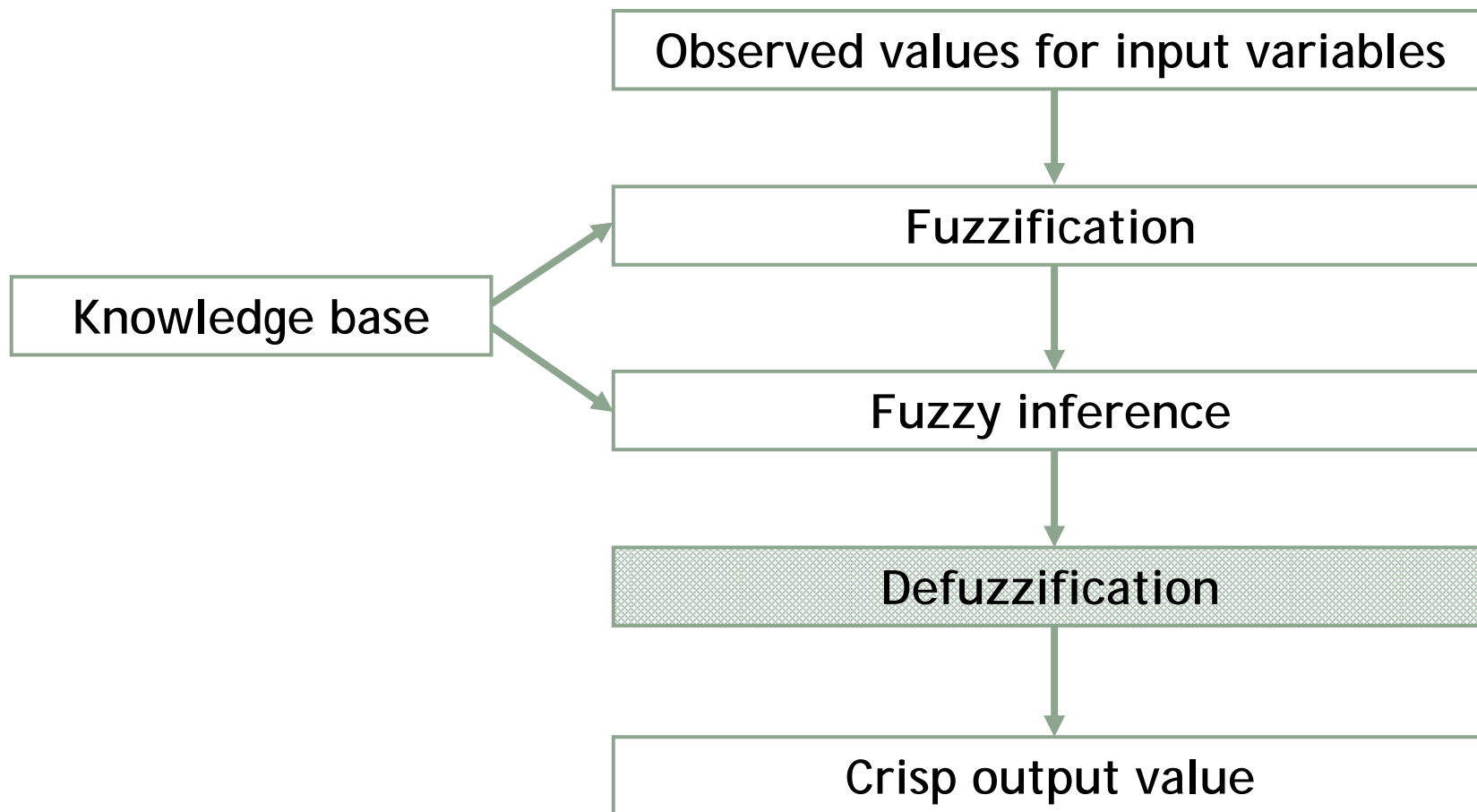
➢ In common set theory a value is member in a set or not, i.e. a statement is true (1) or false (0).

➢ Fuzzy set theory allows for statements that can be **partially true and partially false** at the same time. This means a value is with degrees between 0 and 1 member in one or more sets. Such a value is called a **fuzzy value**.

➢ The degree to which a fuzzy value is a member in a set is defined by **membership functions**.

Key ideas a fuzzy logic - membership function

$$T(\ age\ ) = \{\ very\_young\ , young\ , middel\ , old\ , very\_old\ \}$$

Architecture of a Fuzzy Inference System

Observed values for input variables

↓

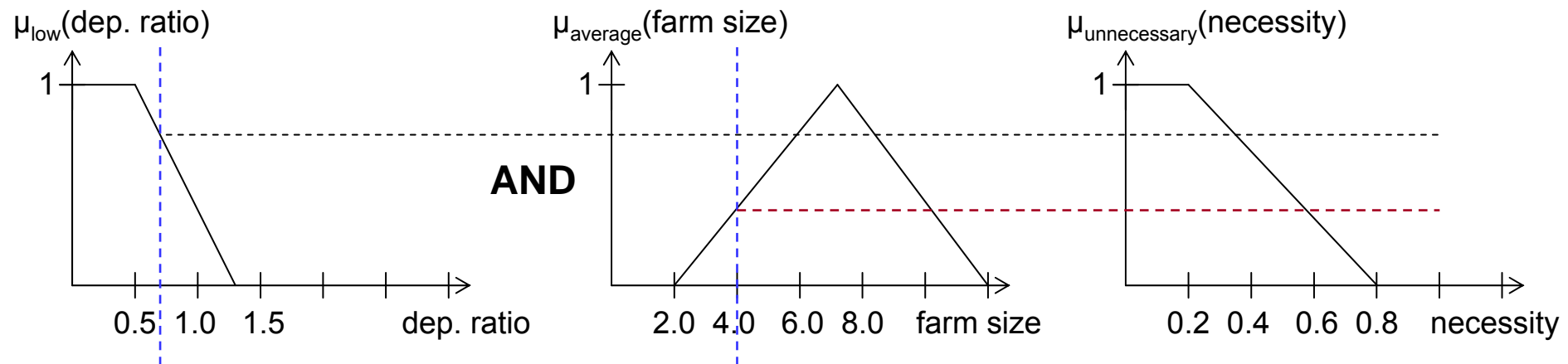Knowledge base

Fuzzification

↓

Fuzzy inference

↓

Defuzzification

↓

Crisp output value

Key ideas of fuzzy logic - rules

Rule 1:   IF dep. ratio=low AND farm size=average THEN necessity=unnecessary

dep. ratio=0.75
farm size=4.0 ha

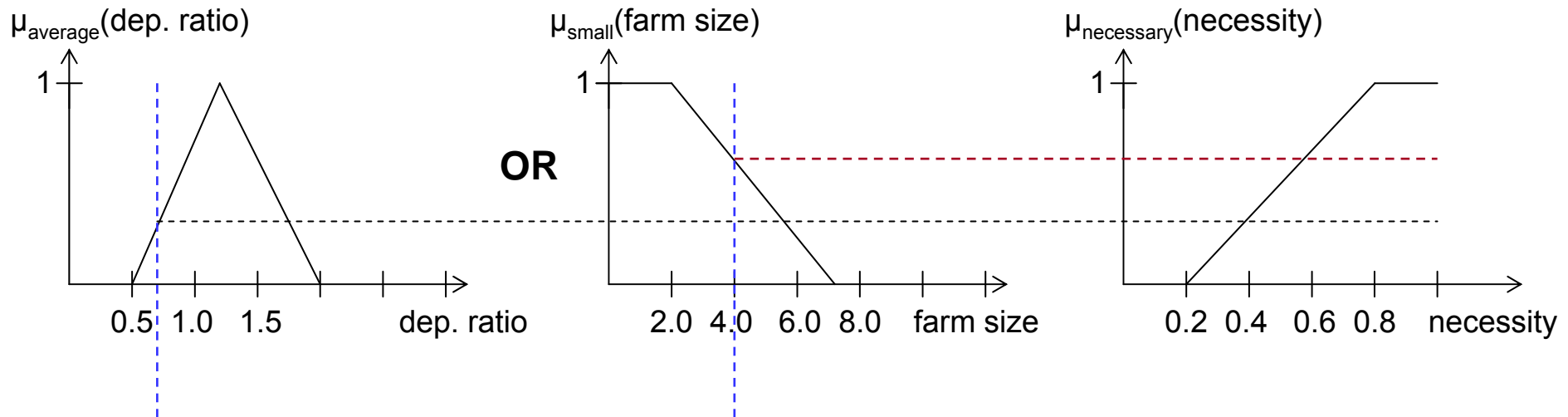μ_{low}(dep. ratio) $\mu_{average}$(farm size) $\mu_{unnecessary}$(necessity)
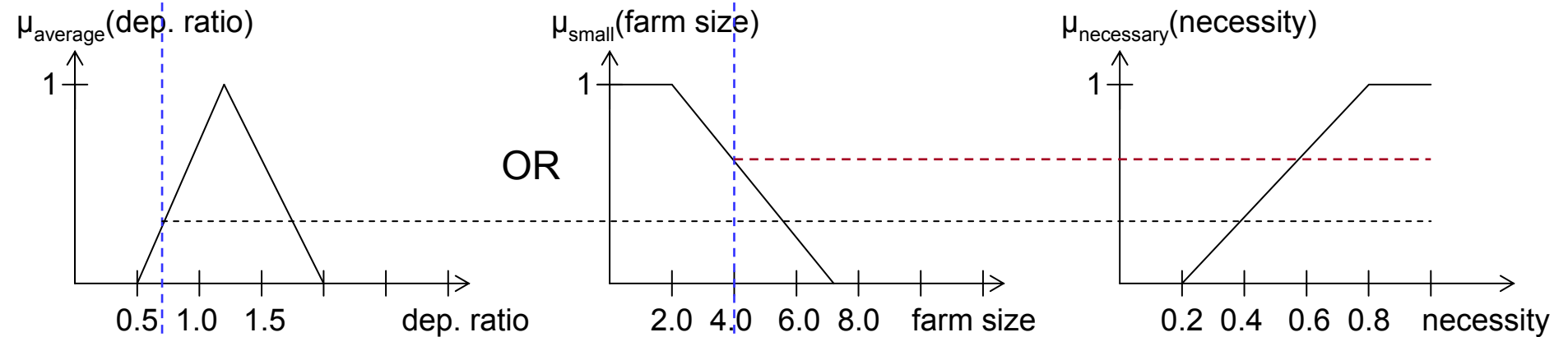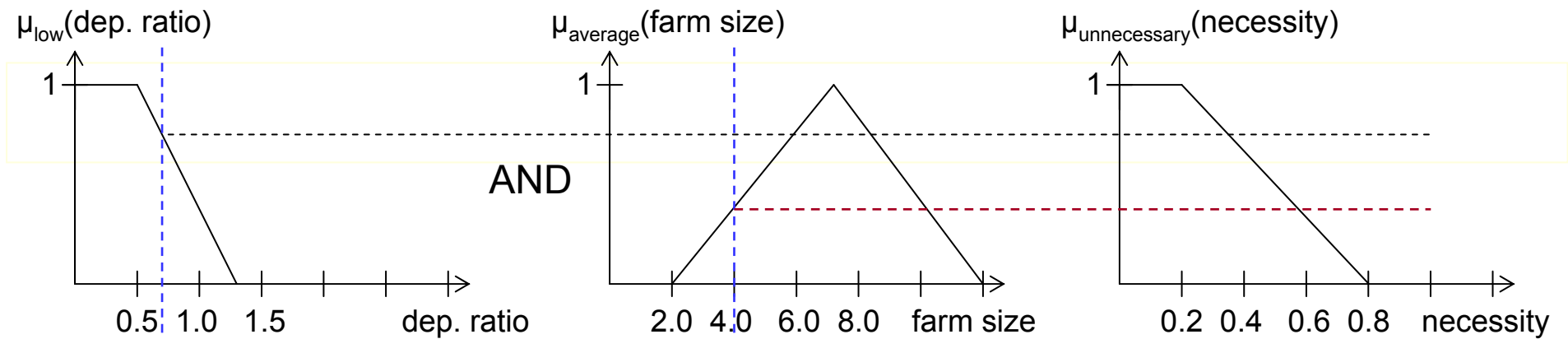
AND

Key ideas of fuzzy logic - rules

Rule 2: IF dep. ratio=average OR farm size=small THEN necessity=necessary

dep. ratio=0.75
size=4.0 ha

μ_{low}(dep. ratio) $\mu_{average}$(farm size) $\mu_{unnecessary}$(necessity)

AND

0.5 1.0 1.5   dep. ratio

2.0 4.0 6.0 8.0   farm size

0.2 0.4 0.6 0.8   necessity

$\mu_{average}$(dep. ratio) μ_{small}(farm size) $\mu_{necessary}$(necessity)

OR

0.5 1.0 1.5   dep. ratio

2.0 4.0 6.0 8.0   farm size
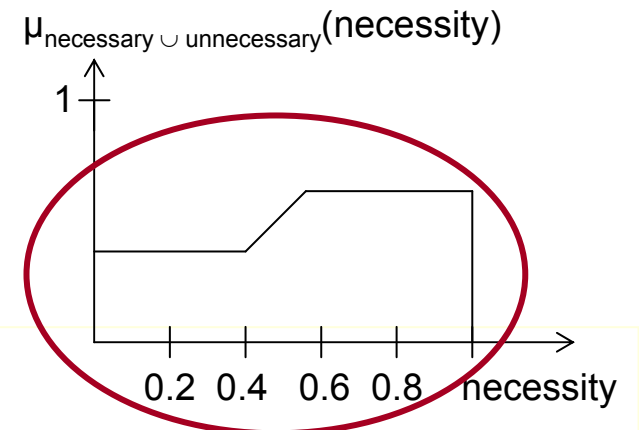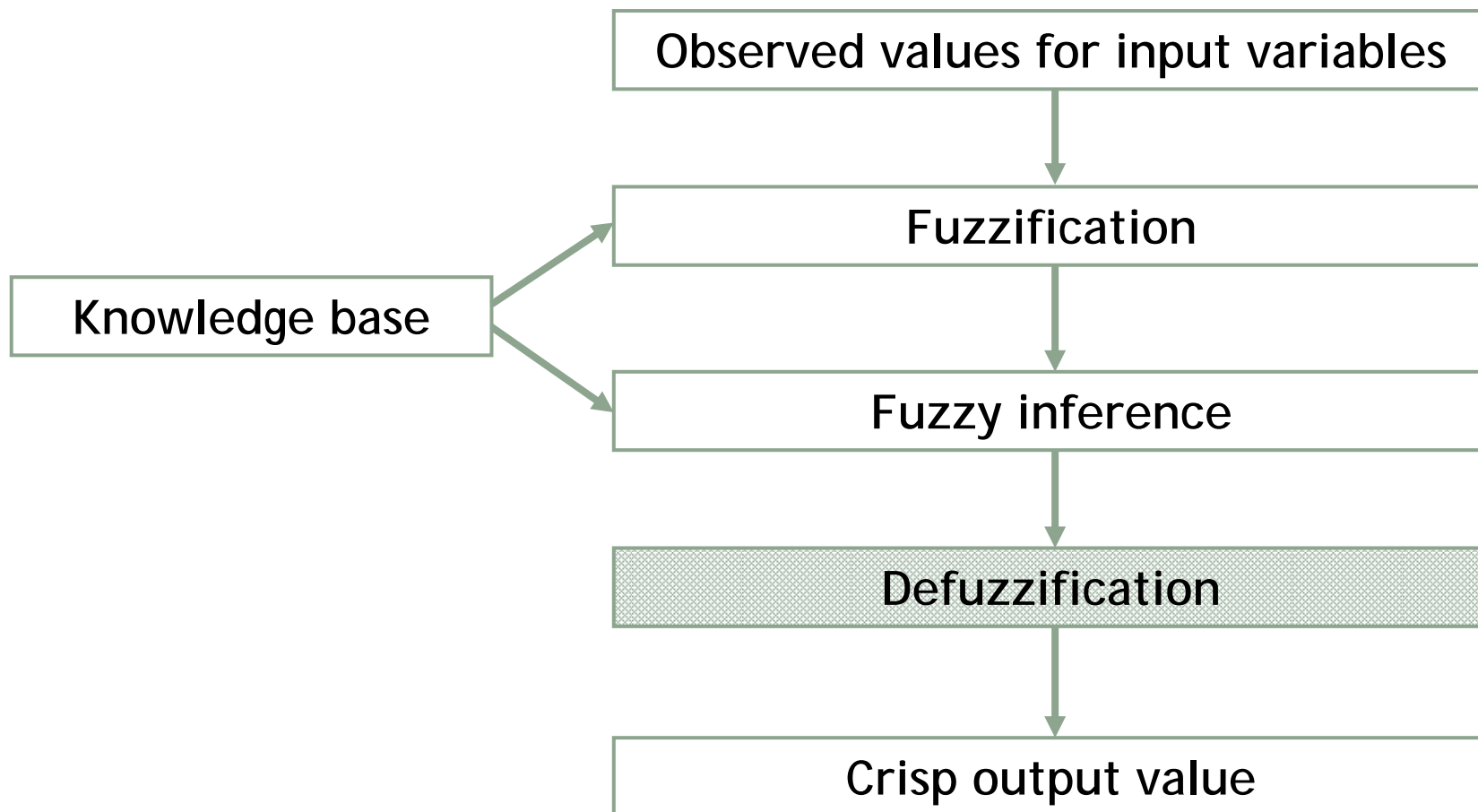
0.2 0.4 0.6 0.8   necessity

Rule 1:   IF dep. ratio=low AND farm size=average THEN necessity=unnecessary

Rule 2:   IF dep. ratio=average OR farm size=small THEN necessity=necessary

result for dep. ratio=0.75 and farm size=4.0 ha in output set

$\mu_{necessary \cup unnecessary}$(necessity)

0.2 0.4 0.6 0.8   necessity

Architecture of a Fuzzy Inference System

Observed values for input variables

Knowledge base

Fuzzification

Fuzzy inference

Defuzzification

Crisp output value

Defuzzification

- ➢ Centre of area (CoA), centre of gravity (CoG)
- ➢ Centre of maxima (CoM)
- ➢ Smallest of maxima (SoM), mean of maxima (MoM), largest of maxima (LoM)

$\mu_{necessary \cup unnecessary}(necessity)$

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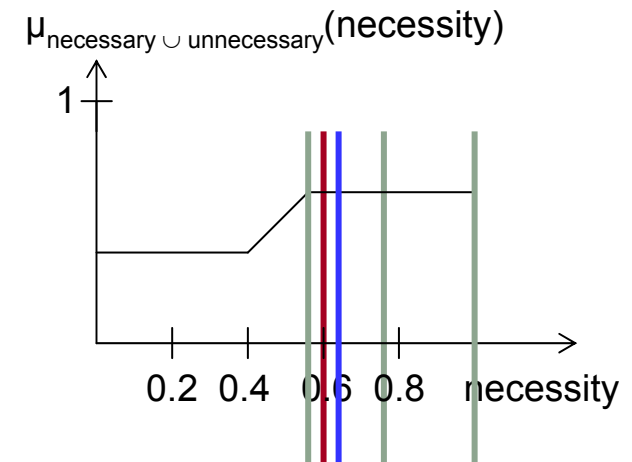
- Zadeh, L.A. (1965): Fuzzy sets, Information and Control 8: 338-353.

- Smithson, A. and Verkuilen, J. (2006): Fuzzy Set Theory. Applications in the Social Sciences, Quantitative Applications in the Social Sciences, No. 07-147, Sage Publications, Thousand Oaks, USA.

- Sivanandam, S.N., Sumathi, S., Deepa, S.N. (2007): Introduction to Fuzzy Logic using MATLAB, Springer, Berlin, Germany.

- Handbooks fuzzyTECH and Fuzzy Logic Toolbox

- Standard IEC 1131-7 (1997), draft version, www.fuzzytech.com

3. Application - theory

The integrated framework for the analysis of non-farm rural employment (NFRE)
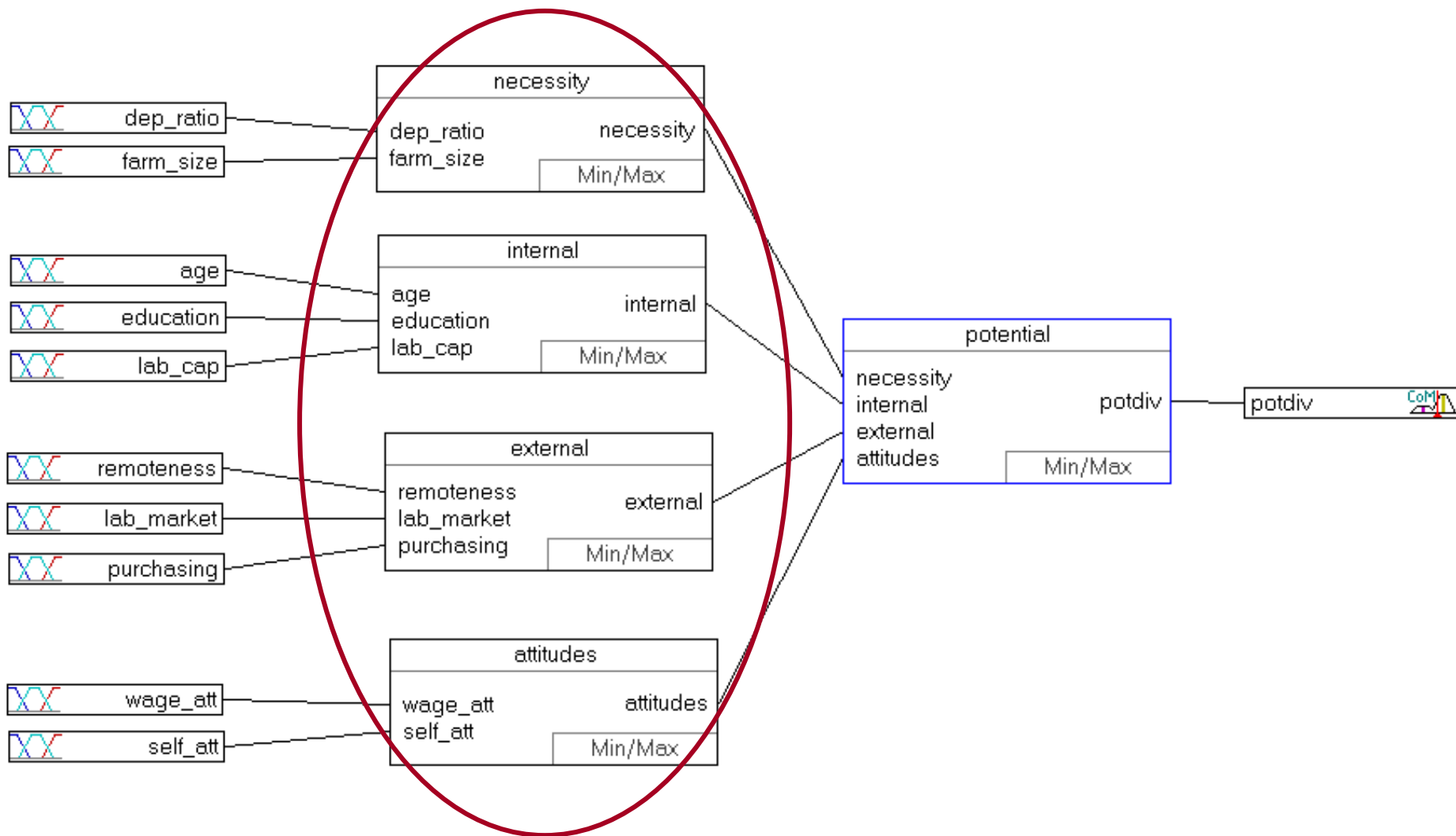

... structure & institutions influence context and livelihood assets ...
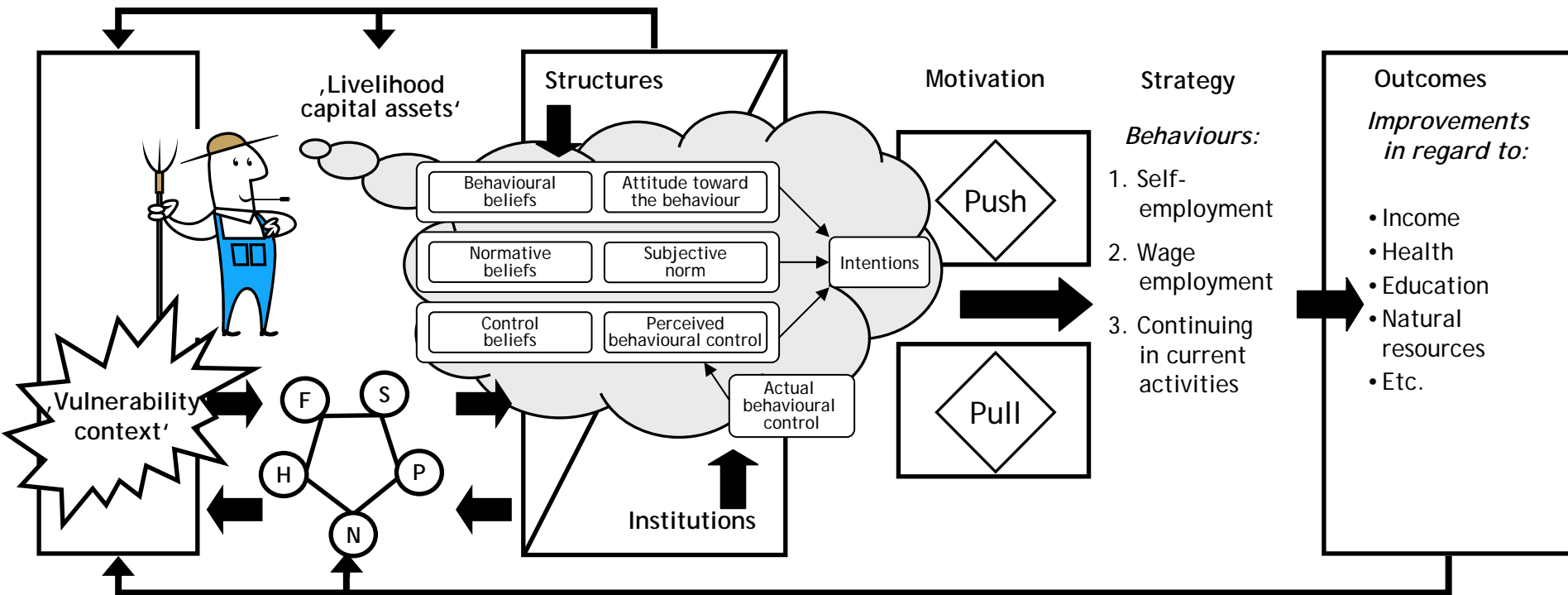
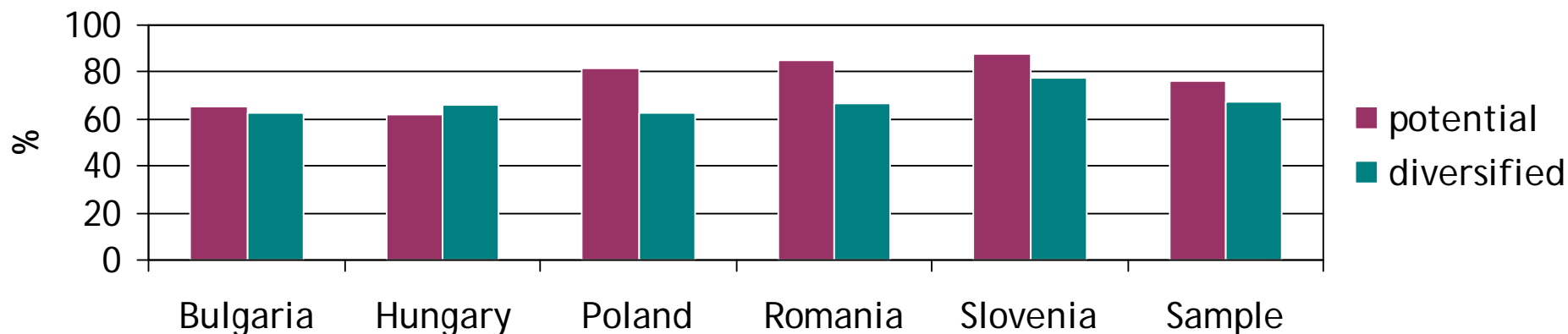... outcomes influence vulnerability context and livelihood assets ...

Source: Möllers (2006, p. 78) with adaptations.

3. Application - results

> N=1,077 farm households in Bulgaria, Hungary, Poland, Romania, and Slovenia

> Data from SCARLED household surveys

> 76.2% potential households
>   from 61.9% (Hungary) to 87.8% (Slovenia)

> 67.1% diversified households
>   from 62.8% (Bulgaria and Poland) to 77.5% (Slovenia)

3. Application - results

		Potential of non-farm diversification	
		Yes	No
Actually diversified	Yes	633 households 58.8%	90 households 8.4%
	No	188 households 17.4%	166 households 15.4%

➢ 74.2% of households "correctly" classified

➢ Households in the four groups show specific characteristics

3. Application - results

		Potential of non-farm diversification	
		Yes	No
Actually diversified	Yes	**Rural diversifiers** and **demand-pull diversifiers**	**Past demand-pull diversifiers**
	No	**Rural newcomers**, **farmers**, and **survey and model error**	**Farmers** and households living under distress-push conditions

4. Conclusions

➢ Fuzzy logic implements the common way of thinking and could be a solution for many problems.

➢ Rules help to communicate complex issues to outsiders.

➢ Diversification model depicts current situation well.

➢ It worth to think about applications in policy analysis.

Thank you for your attention!