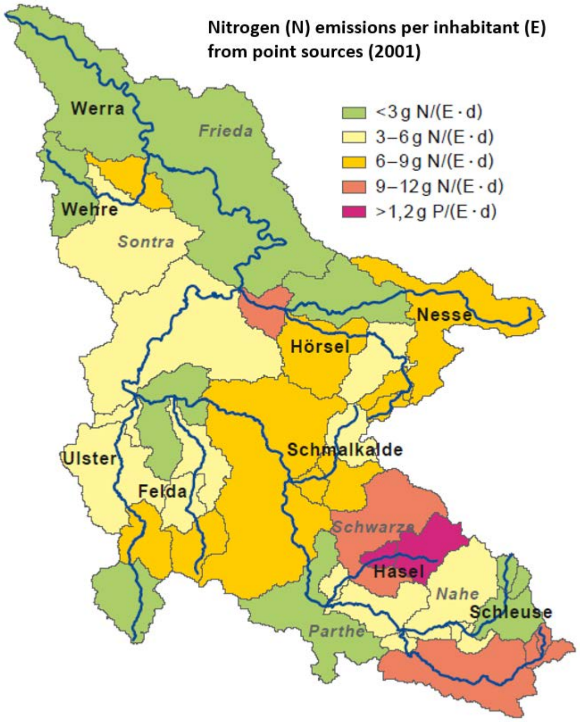

Scaling issues in multi-criteria evaluation of combinations of measures for integrated river basin management

Jörg Dietrich & Rania Taha

Institute for Water Resources Management,
Hydrology and Agricultural Hydraulic Engineering

Leibniz Universität Hannover

IAHS AISH

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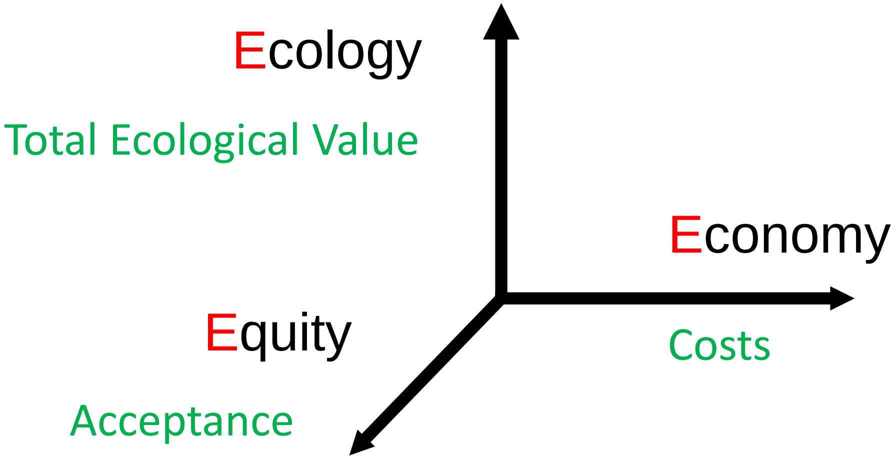
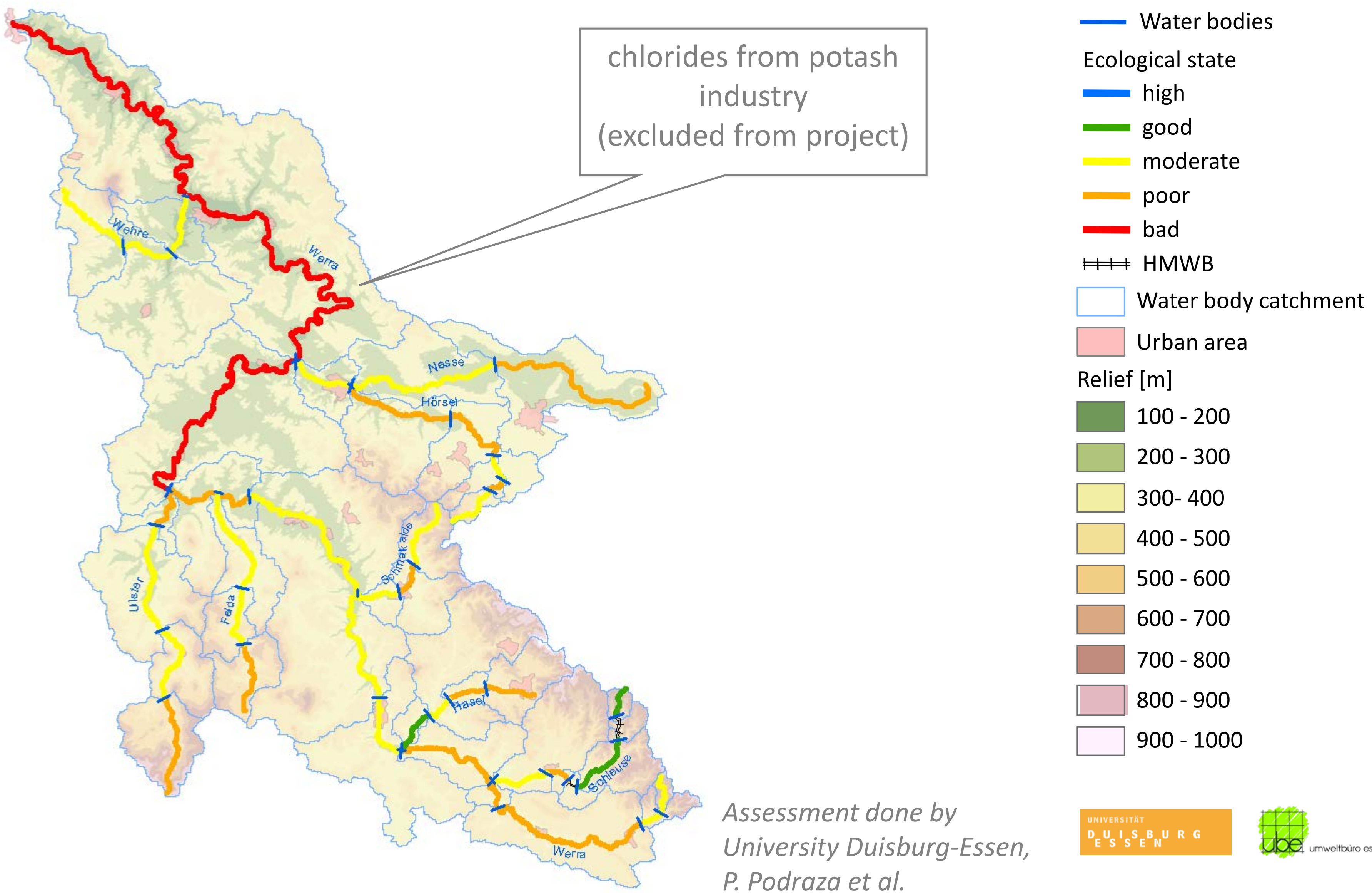
1 Integrated assessment of measures: IWRM Werra case study

- EU WFD RBMP
- Joint Research Project
- PI: A. Schumann, 2002-2005

- Scene
  - Goal: reach/maintain good ecological state by 2015
  - Scale: water body (41) to Werra catchment work area



IWRM Werra: Ecological Quality Assessment



Assessment done by University Duisburg-Essen, P. Podraza et al.

Combinations of measures for the RBMP: ST+HM+CR

- ST1: first reduce point sources, then diffuse sources

  Idea: lower cost and better predictability of the consequences of measures at point sources;

- ST2: first reduce diffuse sources, then point sources

  Idea: make use of combined beneficial effects from reducing diffuse sources by hydro-morphological structures like riparian buffers;

- ST3: polluter oriented distribution of measures

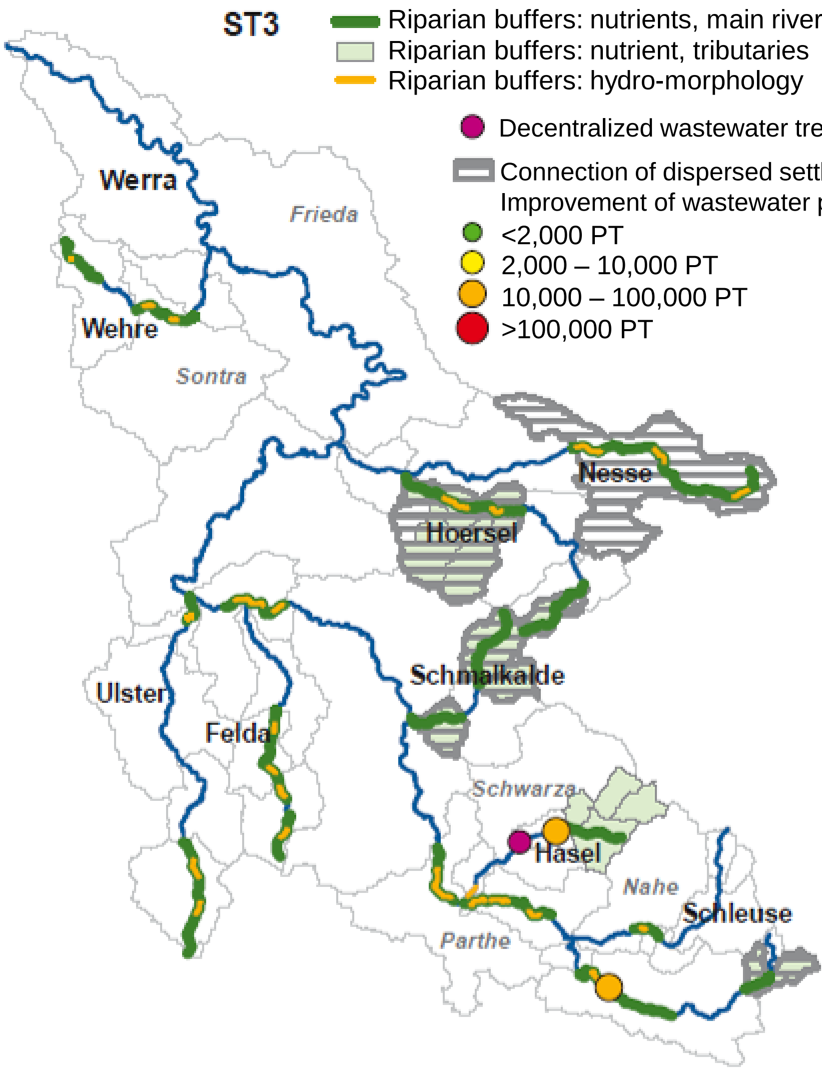
  Idea: strictly follow the "polluter pays" principle;

- ST4: most cost efficient allocation of measures

  Idea: economic optimization of the overall RBMP.

- Hydromorphology and ecological continuity measures: one combination identified as best overall (HM9)

Combinations of measures for nutrient reduction



Ecological Benefit Assessment

- Total economic value TEV (in monetary units) includes use-values and non-use values of natural systems *(Turner et al. 2003)*
- Biodiversity, improvement of river structures, recreation
- Benefit transfer: values for willingness to pay and replacement costs taken from studies in other catchments
- Project duration 20 years, 3% interest rate, 1 degression in biodiversity benefit
- Aggregation in space:
  - Local component
  - Regional component (only applies when catchment gets good status)
  - Weighting of water bodies for catchment assessment: additive, but length was included in equation for TEV per water body

Sozio-economic assessment done by IÖW – Dehnhardt, Hirschfeld (Hirschfeld et al 2005)

Social Acceptance Assessment

- Dynamic actor network analysis (DANA), questionnaires from a representative group of stakeholders of different sectors (tourism, agriculture, nature protection, fishers) (Bots et al. 1999)
- Perception of actors regarding the proposed measures
- The cooperation index incorporates a) the degree of being affected by potential measures; b) the acceptance of the potential measures; c) the relevance of the affected uses in the region and d) the question of who will bear the costs
- Aggregation in space:
  - Computation of “cooperation index” for each water body
  - Weighting of water bodies according to population

2 Spatial aggregation – first criteria or first space?

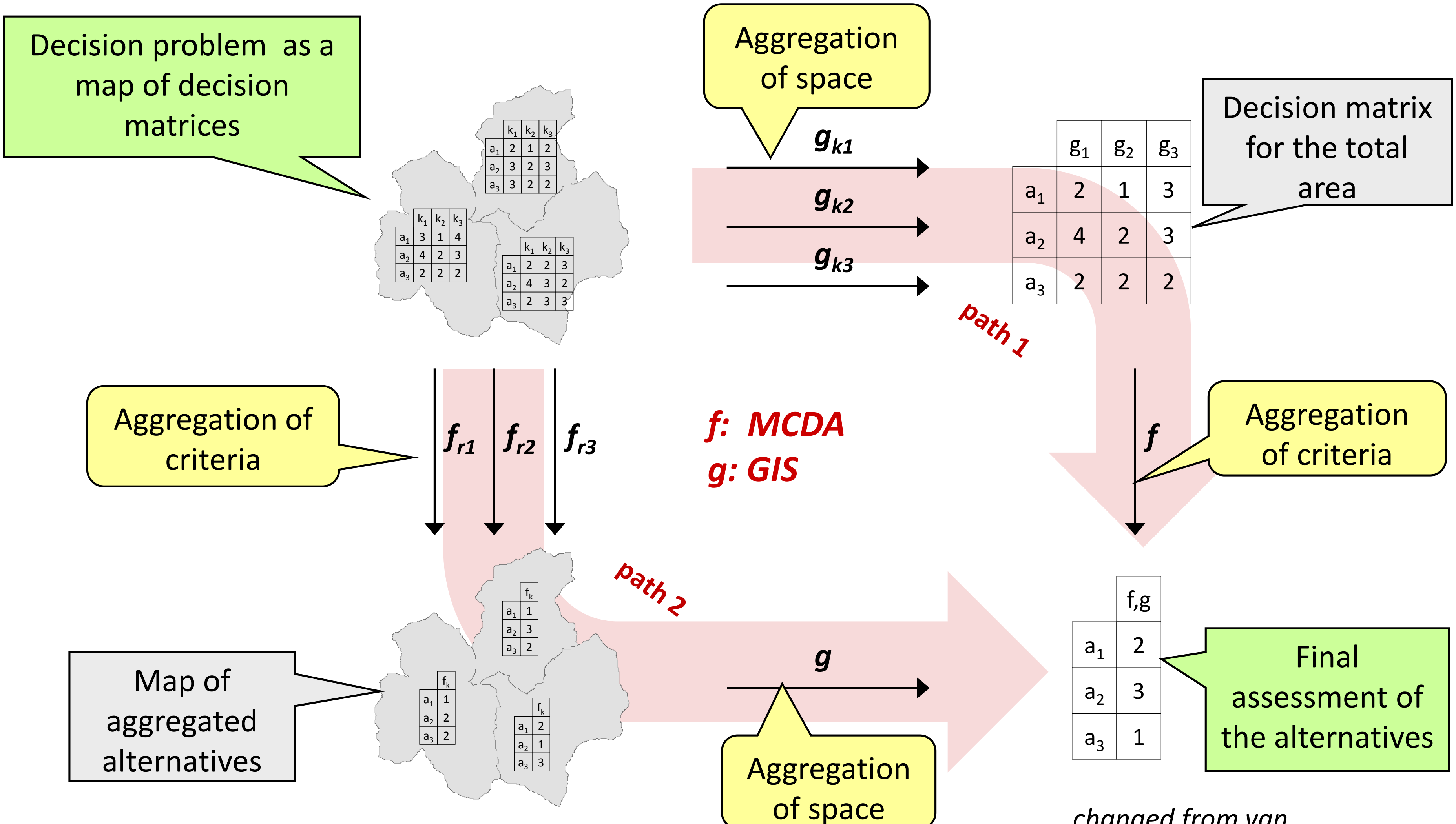
1st space: aggregate all criteria from water bodies to work area, then apply MCDA for ranking

1st criteria: ranking of alternatives for each water body, aggregate ranks to work area

hypotheses:

- Both path ways can lead to different results
- "1st criteria" better preserves local preferences

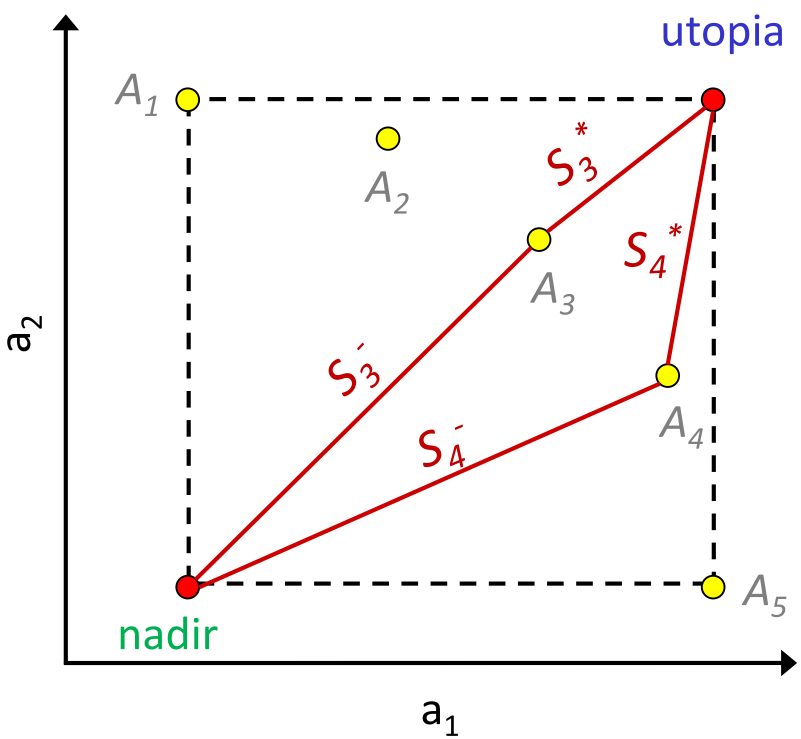
Spatial Aggregation of Criteria



changed from van Herwijnen & Rietveld (1999)

Aggregation of criteria: TOPSIS

- Technique for Order of Preference by Similarity to Ideal Solution: ideal point method *(Hwang & Yoon 1981)*



- Separation measure *S* (Euclidian distance from utopia/nadir)

$$S_i^{*,-} = \sqrt{\sum_{J=1}^{n} w_j\left(\max|min(a_{i,j}) - a_{i,j}\right)^2}$$

i	alternatives	*w*	*weights*
j	criteria	*a*	decision variables

- Relative closeness *C* to ideal solution

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-}$$

Results path 1 vs. path 2 with TOPSIS

	1: space -> MCDA	2: MCDA -> space	Decision matrix		
alternative	rank	rank (pop weight)	cost [M€]	benefit [M€]	acceptance
ST1	1	2	52,7	113,5	7,59
ST2	3	3	62,0	118,5	7,60
ST3	4	4	99,9	118,3	7,24
ST4	2	1	53,9	127,6	7,65

Explanations?

ST3: land use conversion - expensive and conflicts!

ST1: cost and measures spatially imbalanced
(focus on point sources: Eastern German sewage systems)

ST4: well balanced distribution of measures

Discussion and Conclusions

- Hypotheses
  - Both aggregation path ways can lead to different results -> yes
  - 1st criteria better preserves local preferences -> (yes?)
- Dependencies between criteria
  - Financial resources define environmental options
  - Social criteria like “cooperation index”: double counting preferences?
- Uncertainty
  - Not computed here
  - Challenging with socio-economic criteria
- Further work
  - Different weighting procedures in spatial aggregation
  - Application of different MCDA techniques

Thank you for your attention!

Contact: Dr.-Ing. Jörg Dietrich

Institute for Water Resources Management, Hydrology and Agricultural Hydraulic Engineering, Leibniz University Hannover

dietrich@iww.uni-hannover.de, Tel. +49-(0)511-762-2309

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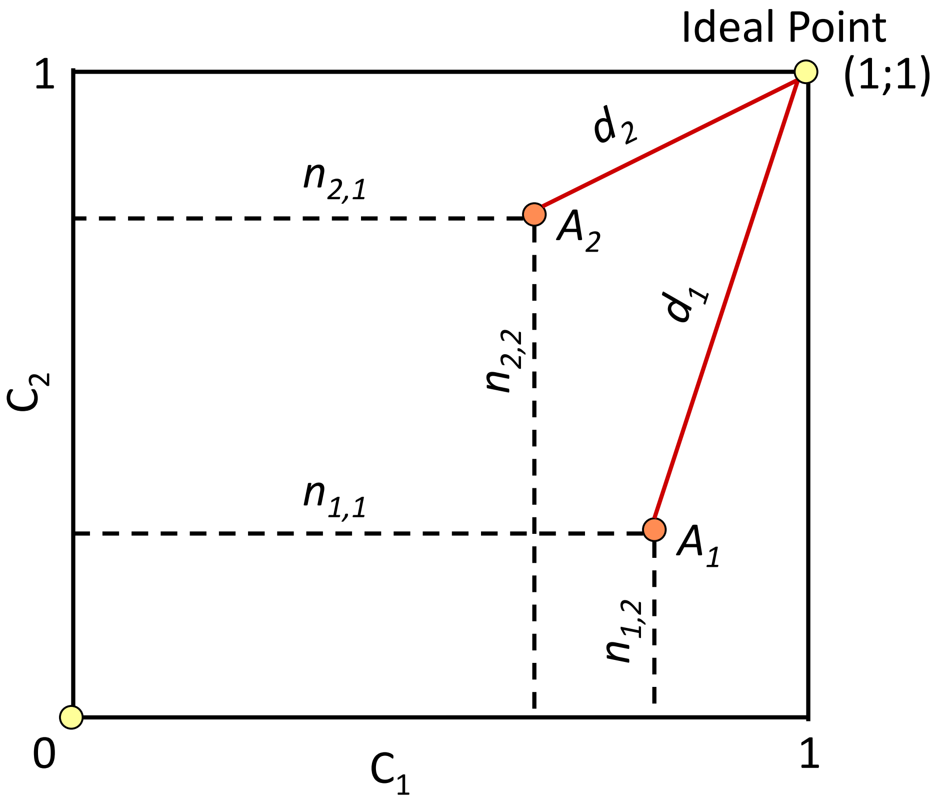
Compromise Programming

- Distance based method.
- Overall performance of each alternative is computed as sum of weighted distances of partial goals to an ideal point.



n_{ik} performance for alternative *i* and criterion *k* (partial goal)

(0 no ... 1 full performance)

d_i distance of alternative *i* to the ideal point (Pythagoras' theorem)

$$d_i = \sqrt{\sum_{k=1}^{2} (1 - n_{ik})^2} \quad (3)$$

Fig. 6: Geometric scheme of distance based methods

Multi-Criteria Decision Analysis (MCDA)

- Should integrate economy, environment, regional development and social welfare
- Like analytical project assessment methods, MCDA should a) be reproducible, b) quantify, c) support an iterative process between decision makers and stakeholders
- Performances of single alternatives are compared as well as several alternatives are compared according to the performance of the respective single criterions.
- A bad performance of one alternative according to one criterion can be compensated by a better performance of another criterion.
- The solution is a compromise!