Real-Life Examples of MADM Applications

Aims:
To get a feeling for MADM models
To see the potential of MADM in practice

Some Application Areas

1. INFORMATION TECHNOLOGY
   - evaluation of computers
   - evaluation of software
   - evaluation of Web portals
2. PROJECTS
   - evaluation of projects
   - evaluation of proposal and investments
   - product portfolio evaluation
3. COMPANIES
   - business partner selectioon
   - performance evaluation of companies
4. PERSONNEL MANAGEMENT
   - personnel evaluation
   - selection and composition of expert groups
   - evaluation of personal applications
5. MEDICINE and HEALTH-CARE
   - risk assessment
   - diagnosis and prognosis
6. OTHER AREAS
   - assessment od technologies
   - assessments in ecology and environment
   - granting personal/corporate loans

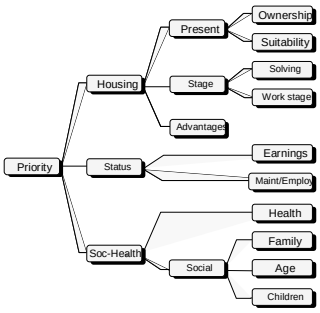
Allocation of Housing Loans

- Housing Fund of the Republic of Slovenia:
  Allocation of housing loans to citizens and nonprofit organizations
- Since 1991: 21 completed floats of loans for citizens (*recurring* decision problem)
- Management decision support system for housing loan allocation
- Evaluation of loan priority: qualitative multi-attribute decision models (DEX)
- 2/3 of housing loans in Slovenia are allocated in this way

M. Bohanec, B. Cestnik, V. Rajkovič, Qualitative Multi-Attribute Modelling and its Application in Housing. *Journal of Decision Systems* 10, 2001.

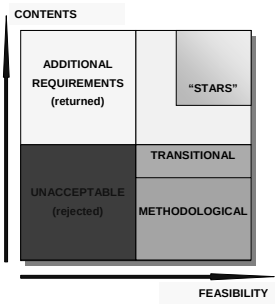
Allocation of Housing Loans

Multi-Attribute Model Structure



Evaluation of R&D Projects

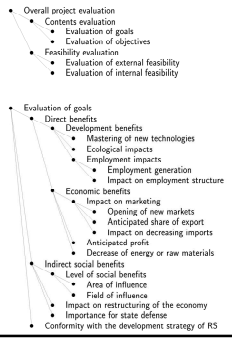
Slovenian Ministry of Science and Technology



M. Bohanec, V. Rajkovič, B. Semolič, A. Pogačnik: Knowledge-based portfolio analysis for project evaluation. *Information & Management* 28(5), 1995, 293-302.

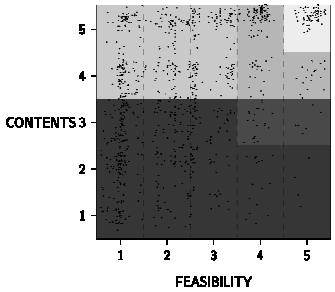
Evaluation of R&D Projects

Multi-Attribute Model Structure (partial)



Evaluation of R&D Projects

Evaluation of projects in 1992:
516 projects: 1094 reviews contributed by 90 reviewers



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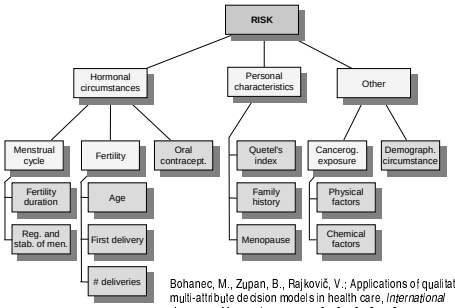
Medicine: Breast Cancer Risk Assessment



Bohanec, M., Zupan, B., Rajkovič, V.: Applications of qualitative multi-attribute decision models in health care, *International Journal of Medical Informatics* 58-59, 191-205, 2000.

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An Example of Decision Rules

	Fertility duration	Reg. and stabil. of menstruation	Menstrual cycle
1	average	R-28	high risk
2	long	R-28	high risk
3	long	R29+	high risk
4	long	N	high risk
5	short	R-28	moderate risk
6	average	R29+	moderate risk
7	short	R29+	low risk
8	short	N	low risk
9	average	N	low risk

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Average Importance of Attributes

BREAST CNCER RISK	Regression	Informativity	Gini Index
Hormonal circumstances	**158**	**202**	**234**
Menstrual cycle	**125**	**123**	**130**
Fertility duration	**125**	**128**	**138**
Reg./stab. menstruation	75	72	62
Fertility	111	99	130
Age	97	145	126
First delivery	**145**	**128**	**145**
# deliveries	58	27	29
Oral contraceptives	65	78	41
Personal characteristics	88	56	39
Quetel's index	29	5	11
Family history	**197**	**183**	**236**
Menopause	74	112	53
Other	55	42	27
Cancerogenic exposure	100	100	100
Physical factors	**160**	**166**	**179**
Chemical factors	40	34	21
Demographical circumst.	100	100	100

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Evaluation and Analysis of Options

	Basic evaluation	Missing data	"What-if" analysis
BREAST CANCER RISK	**3**	**3**	2
Hormonal circumstances	2	3/0,5,2/0,5	2
Menstrual cycle	moderate risk	moderate risk	moderate risk
Fertility duration	average	average	average
Reg./stab. menstruation	R29+	R29+	R29+
Fertility	moderate risk	moderate risk	moderate risk
Age	over 40	over 40	over 40
First delivery	29 or younger	29 or younger	29 or younger
# deliveries	up to 4	up to 4	up to 4
Oral contraceptives	no	*	no
Personal characteristics	1	1	1
Quetel's index	29+	29+	29+
Family history	no	no	no
Menopause	no	no	no
Other	high risk	high risk	moderate risk
Cancerogenic exposure	high risk	high risk	moderate risk
Physical factors	higher	higher	lower
Chemical factors	no	*	no
Demographical circumstances	high risk	high risk	moderate risk

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Selective Explanation of Options

Reasons FOR **higher risk**		**Reasons** AGAINST **higher risk**	
Age	over 40	Personal characteristics	1
Quetel's index	29+	Family history	no
Other	high risk	Menopause	no
Cancerogenic exposure	high risk	First delivery	29 or younger
Physical factors	higher	Oral contraceptives	no
Demographic circumst.	high risk	Chemical factors	no

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Diabetic Foot Risk Assessment

Who:
- General Hospital Novo Mesto, Slovenia
- IJS
- Infonet, d.o.o.

Why:
- Reduce the number of amputations
- Improve the risk assessment methodology
- Improve the DSS module of clinical information system

How:
- Develop multi-attribute risk assessment model
- Evaluate it on patient data (about 3400 patients)
- Integrate into the clinical information system

In: Mladenić, D., Lavrač, N., Bohanec, M., Moyle, S. (eds.): *Data mining and decision support: Integration and collaboration.* Kluwer Academic Publishers, 2003.

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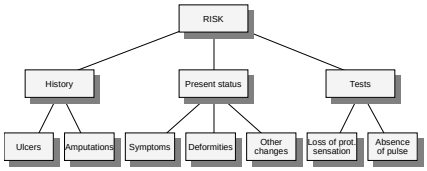
Diabetic Foot Risk Assessment

Risk Assessment Model



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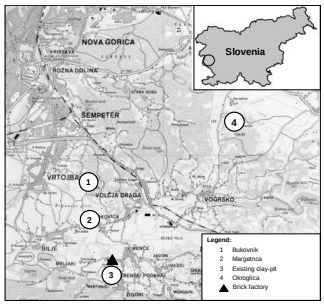
Environmental: Clay-Pit Location



Bohanec, M., Rajkovič, V.: Multi-attribute decision modeling: Industrial applications of DEX, *Informatica* 23, 487-491, 1999.

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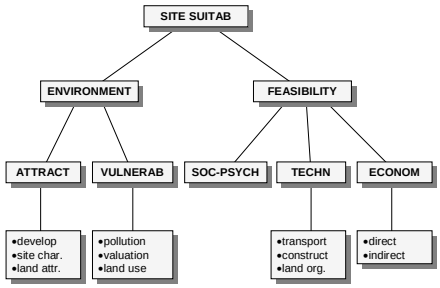
Clay-Pit Location Model



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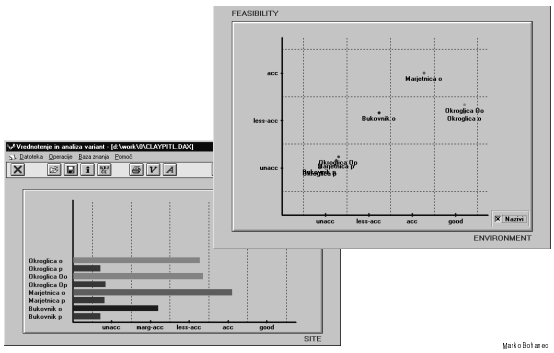
Clay-Pit Location Evaluation



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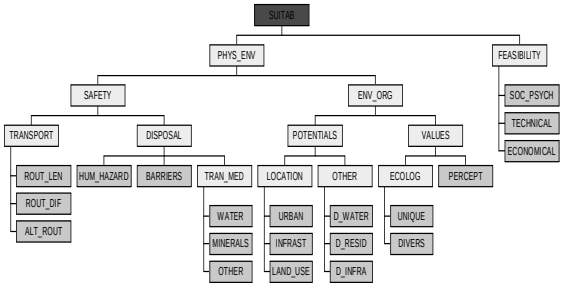
Environmental: Location of a Radioactive Waste Repository



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Advising Children in Choosing Sports

Talent:

- A knowledge-based computer program
- for advising children in choosing sports
- in primary and secondary schools

Leskošek, B., Bohanec, M., Rajkovič, V.: The use of expert methods in the orientation of children into different sports, *Acta Universitatis Carolinae, Kinanthropologica* 38(2), 33-44, 2002.

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Database of Measurements

GENERAL DATA	
	Age
	Gender
	Date of measurement

MORPHOLOGICAL TESTS	
BH	Body height (cm)
BW	Body weight (kp)
SF	Skin fold of the upper arm (mm)

MOTORIC TESTS	
TAP	Taping with hand (number)
SJ	Standing jump (cm)
PB	Polygon backwards (s)
SU	Sit up of the trunk (number)
DB	Deep bend on bench (cm)
BAH	Bent arm hang on horizontal bar (s)
S60	60 m sprint (s)
R600	600 m run (s)

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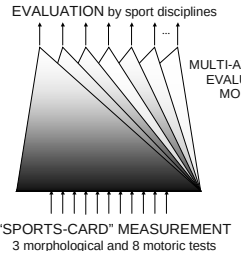
Talent: Basics



23 disciplines:

athletics (5 disciplines)
swimming (4)
skiing (3)
football
volleyball
handball
tennis
badminton
...

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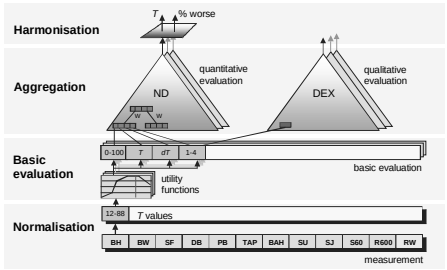
Evaluation Models



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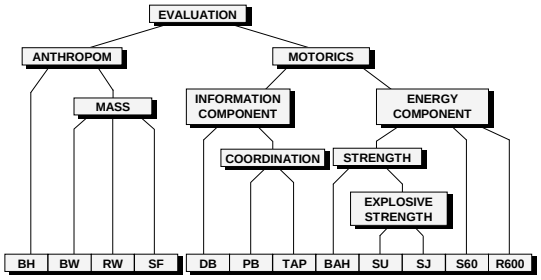
Evaluation Model Structure



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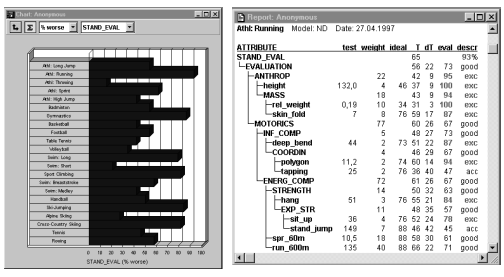
Evaluation and Explanation



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Decision Problem: Housing (1/2)

Client:
The Housing Fund of the Municipality of Ljubljana

Task:
Support a tender for renovating old denationalized blocks of flats in Ljubljana

Problem characteristics:
– one-time problem

In: Mladenić, D., Lavrač, N., Bohanec, M., Moyle, S. (eds.): *Data mining and decision support: Integration and collaboration.* Kluwer Academic Publishers, 2003.

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Decision Problem: Housing (2/2)

Earmarked financial resources:
600 M SIT (3 M €)

Timing: December 1999 – September 2000

Phases of the project:
1. application gathering
2. (in)completeness notification
3. application completion
4. loan approval and allocation
5. notifying applicants
6. handling complaints

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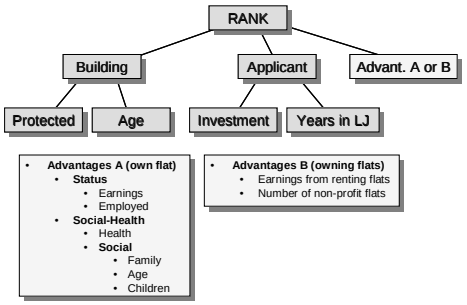
DEX Application Ranking Model:
Model Structure



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DEX Application Ranking Model:
Decision Rules

Investment part	Years in Ljubljana	APPLICANT
(1) 40-50	(1) less than 10	(1) normal
(2,3) 50-100	(1) less than 10	(2) priority
(1) 40-50	(2) 10-20	(2) priority
(2) 50-60	(2,3) over 10	(3) high priority
(1,2) 40-60	(3) over 20	(3) high priority
(3) over 60	(2,3) over 10	(4) highest priority

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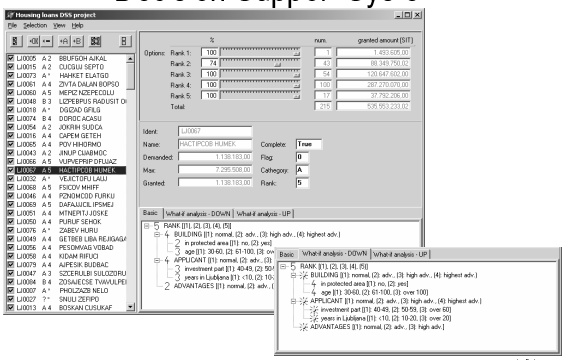
Decision Support System



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Project Characteristics

- **Business sector**: Housing, Investment funding
- **Decision problem type** [one-time vs. recurring]: two-time
- **Problem structure** [structured vs. unstructured]: semi-structured
- **Problem definition**: medium
- **Organisational level**: Tactical/Strategic, Management involved
- **Methods used**: modeling, qualitative ranking/evaluation models, computational models, data browsing/aggregation, what-if analysis
- **Primary DS elements**: data, models
- **Group decision problem**: no (no different interests)
- **Group members**: problem owner: 3 members; decision analysts: 2
- **Time span**: 9 months

- **Models**: 2
  A. 17 attributes: 10 basic, 7 aggregate; 5 ranks
  B. 10 attributes: 6 basic, 4 aggregate; 5 ranks
- **Options**: 109 + 258 = 367

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Banks @ SI Housing Schema

Who:
- Slovenian Housing Fund
- IJS
- Temida

What:
- Evaluate and select banks for SHS
- Distribute rights for loan allocation to banks

Why:
- Difficult and sensitive decision problem

How:
- Combined quantitative/qualitative modelling

In: Mladenić, D., Lavrač, N., Bohanec, M., Moyle, S. (eds.): *Data mining and decision support: Integration and collaboration*. Kluwer Academic Publishers, 2003.

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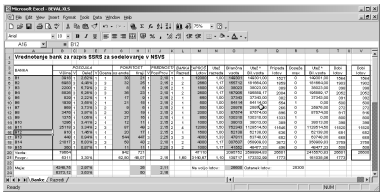
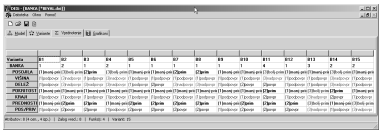
Banks @ SI Housing Schema





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Assessment of Governmental Life-Event Portals

State/Land-Province/City	Internet Address
Europe	
France: Service Publique	http://www.service-public.fr
Italy	http://www.italia.gov.it
Spain	http://www.administracion.es
Great Britain: UKonline	http://www.ukonline.gov.uk
Ireland: Information on the Irish State	http://www.irlgov.gov.ie
Austria: Internet Service HELP	http://www.help.gv.at
German Federal Land Rheinland-Pfalz-Lotse: RLP-Lothse	http://rlp.bund.de/rlp-lotse.htm; http://www.rlp-buergerservice.de
The city of Bremen (Germany): Bremer-online-service	http://www.bremer-online-service.de
Slovenia: e-Uprava	http://e-gov.gov.si/e-uprava/index.html
Rest of the world	
Canada: Government of Canada	http://canada.gc.ca
Singapore: eCitizen	http://www.ecitizen.gov.sg
Hong Kong: Government Services	http://www.info.gov.hk/eindex.htm

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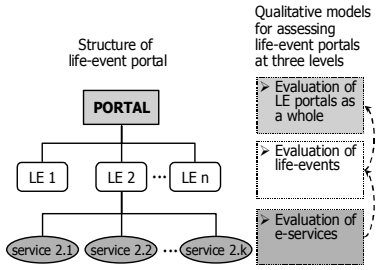
Life-Event Portals
Structure of Models



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Life-Event Portals
Model for Assessment of E-Services

Attribute	Description	Attribute scale
E-service	The final assessment of particular electronic service	**unacceptable**; acceptable; good; ***very good***; ***excellent***
Clarity of e-Service	Level of e-service clarity	**inadequate**; partly adequate; ***adequate***
Information	Assessment of provided information about e-service	**inadequate**; partly adequate; ***adequate***
Inf. Quality	Quality of information	**inadequate**; partly adequate; ***adequate***
Inf. Accessability	Accessability of information	**inadequate**; partly adequate; ***adequate***
Sophistication	Level of service's on-line spohistication (higher than inf.)	**suitable**; partly suitable; suitable; ***very suitable***
Documents	Assessment of document handling	**suitable**; partly suitable; suitable; ***very suitable***
Doc. Accessability	Accessability of documents related to e-service	**suitable**; partly suitable; suitable; ***very suitable***
Downloadable Doc.	Downloadable documents handling	**inadequate**; partly adequate; ***adequate***
Download	Download or printing of forms	**inadequate**; partly adequate; ***adequate***
Send	Documents can be sent by e-mail	**inadequate**; partly adequate; ***adequate***
Interaction	Interactive document handling	**inadequate**; partly adequate; ***adequate***
Interactive Forms	Interactive on-line forms	**inadequate**; partly adequate; ***adequate***
Attachments	Documents can be attached to interactive forms	**inadequate**; partly adequate; ***adequate***
Authentication	Authentication of e-documents	**inadequate**; partly adequate; ***adequate***
Additional Features	Additional fetaures of electronic case handling	**suitable**; partly suitable; suitable; ***very suitable***
Notifying	Notifying about e-service progress in electronic way	**inadequate**; partly adequate; ***adequate***
E-payement	Electronic payement for service is provided	**inadequate**; partly adequate; ***adequate***
E-delivering	E-service's results are delivered electronically	**inadequate**; partly adequate; ***adequate***
E-service Type	Type of e-service	vital; additional

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Life-Event Portals
Model for Assessment of Life-Events

Attribute	Description	Attribute scale
Life-event	The final assessment of life-event (LE)	**unacceptable**; acceptable; good; ***very good***; ***excellent***
Maturity	Level of life-event maturity	**unacceptable**; acceptable; good; ***very good***; ***excellent***
LE Sophistication	Level of life-event sophistication	**unacceptable**; acceptable; good; ***very good***; ***excellent***
Scope of LE	How well LE is covered with services	**inadequate**; partly adequate; ***adequate***
Vital Scope	How well LE is covered with vital services	**inadequate**; partly adequate; ***adequate***
Additional Scope	How well LE is covered with additional services	**inadequate**; partly adequate; ***adequate***
LE Coordination	Level of services' coordination within LE	**dispersed**; ***one-entry point***; step-by-step; ***one-step***
Use of LE	Elements of LE usage	**unsuitable**; partly suitable; suitable; ***very suitable***
Access to Services	Access to services within particular LE	**unsuitable**; partly suitable; suitable; ***very suitable***
Access Instruments	Intstruments to access e-services within LE	**unsuitable**; partly suitable; suitable; ***very suitable***
Key Steps	List and description of key-steps within LE	**inadequate**; partly adequate; ***adequate***
Check List	Check list	**inadequate**; partly adequate; ***adequate***
FAQ	Frequently asked questions	**inadequate**; partly adequate; ***adequate***
E-guide	Intelligent electronic guide through life-event	**inadequate**; partly adequate; ***adequate***
Standardisation of Services	Level of services' design standardisation within LE	**inadequate**; partly adequate; ***adequate***
LE Clarity	How clear LE is presented to the user	**inadequate**; partly adequate; ***adequate***

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Life-Event Portals
Model for Assessment of Portals

Attribute	Description	Attribute scale
Portal	The final assessment of life-event portal (LEP)	**unacceptable**; acceptable; good; ***very good***; ***excellent***
Handling of LE	The way in which life-events (LE) are handled	**unacceptable**; acceptable; good; ***very good***; ***excellent***
Scope of LEP	Level of covering different problems	**inadequate**; partly adequate; ***adequate***
LE Scope	How well LEP is covered with life-events	**inadequate**; partly adequate; ***adequate***
Topics Scope	How well LEP is covered with topics	**inadequate**; partly adequate; ***adequate***
Use of LEP	Different elements of LE portal usage	**unsuitable**; partly suitable; suitable; ***very suitable***
Access to LE	Different instruments leading to particular LE on portal	**unsuitable**; partly suitable; suitable; ***very suitable***
List of LE	List of life-events	**inadequate**; partly adequate; ***adequate***
Hierarchy of Topics	LE is identified through the hierarchy of topics	**inadequate**; partly adequate; ***adequate***
Search Engine	Search engine is offered to find a particular LE	**inadequate**; partly adequate; ***adequate***
Standardisation of LE	Level of LE design standardisation on portal	**inadequate**; partly adequate; ***adequate***

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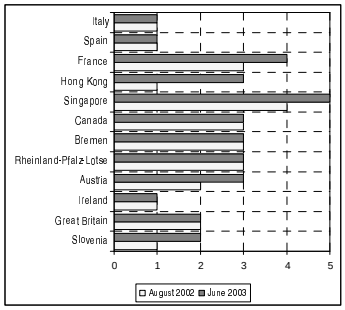
Life-Event Portals
Assessment of Portals in 2002/2003



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Genetically-Modified Crops

ECOGEN
Soil ecological and economic evaluation of genetically modified crops
QLK5-CT-2002-01666 2003-2006 http://www.ecogen.dk/

SIGMEA
Sustainable Introduction of Genetically Modified Crops into European Agriculture
Sustainable introduction of genetically modified crops into European agriculture
FP6-SSP1-2002-502981 2004-2006 http://sigmea.dyndns.org/

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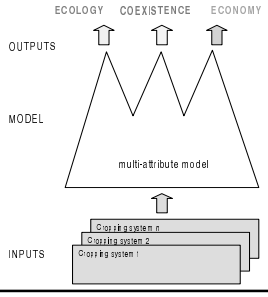
ECOGEN and SIGMEA Models

Evaluating cropping systems in terms of *ecology*, *coexistence* and *economy*



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ECOGEN and SIGMEA Models

1. **"Grignon" model**
   Economic and ecological assessment of GM maize cropping systems
2. **ESQI: ECOGEN Soil Quality Model**
   Assessing the impact of cropping systems on soil quality
3. **SMAC Advisor: SIGMEA Maize Coexistence**
   Decision support software
   Assessing maize coexistence

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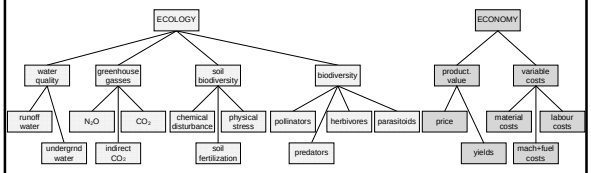
"Grignon" Model
Model Output: Topmost Levels



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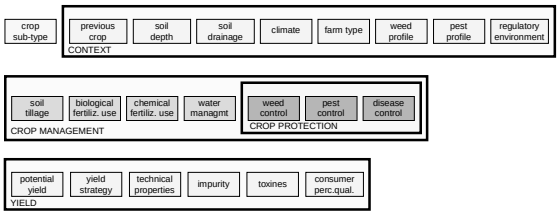
"Grignon" Model
Model Input: Cropping System



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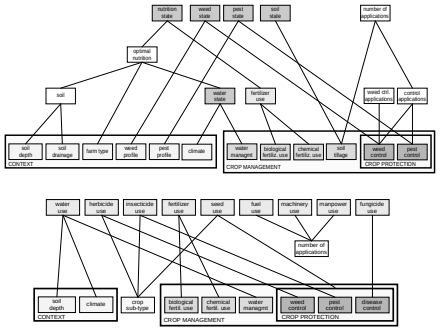
"Grignon" Model
Intermediate Levels: 'State' and 'Use'



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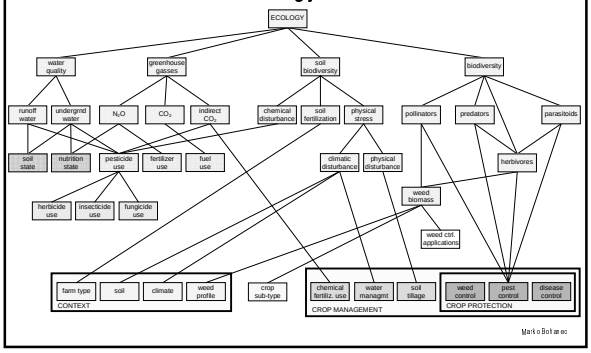
"Grignon" Model
Ecology Part



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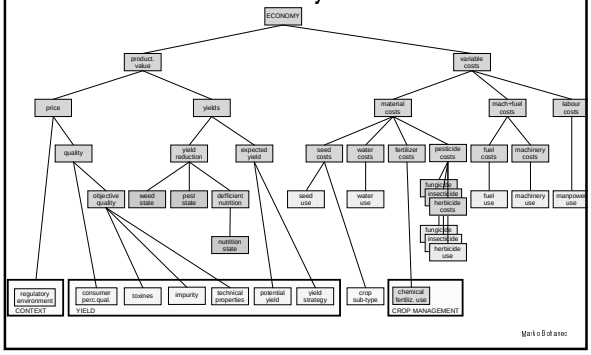
"Grignon" Model
Economy Part



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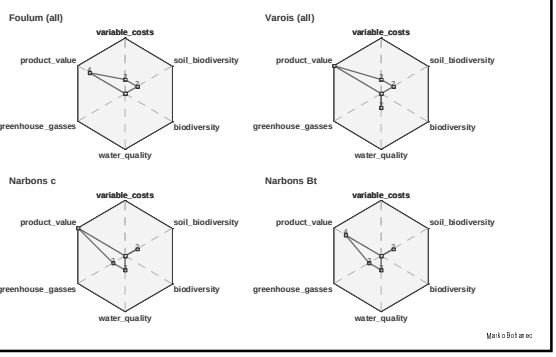
"Grignon" Model
Some Results



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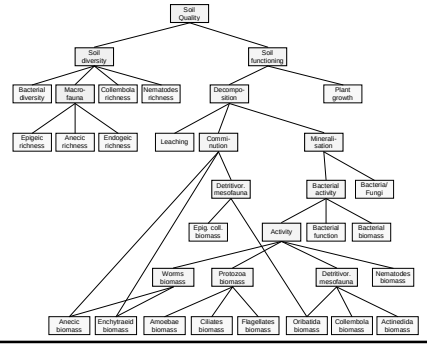
Soil Quality Model
Structure



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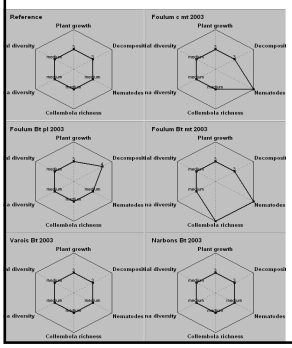
Soil Quality Model
Assessment of ECOGEN Data



- All the options have the same soil quality value of 3
- The use of Bt-maize in Foulum positively effects *Soil functioning* (with ploughing) and *Soil diversity* (when using minimum tillage)
- Minimum tillage positively affects *Nematodes richness*, *Detritivorous mesofauna* and *Protozoa biomass*, leading to better *Activity*
- Bt-maize reduces *Protozoa biomass*, but improves *Comminution* due to *Anecic earthworm biomass*
- At Varois and Narbons, Bt-maize reduced many faunal populations without affecting the higher level outcomes of *Soil functioning*, *diversity* or *quality*

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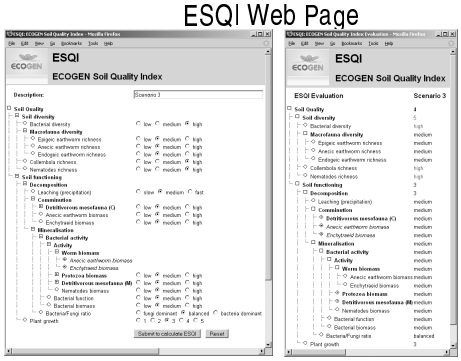
Soil Quality Model
ESQI Web Page



http://ai.ijs.si/MarkoBohanec/ESQI/ESQI.php

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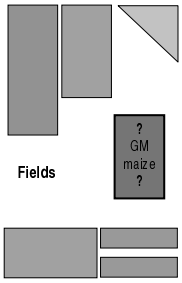
SMAC Advisor
Decision Problem



Problem:
Can GM maize be grown in coexistence with plants on other fields?

Criterion:
Genetic interference (Adventitious Presence)
Typical target AP: 0.9 %

Factors:
pollen flow, volunteers, feral plants, mixing during harvesting, transport, storage and processing, human error, accidents, ...

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SMAC Advisor

Decision support software that *assesses the achievable AP* given:

- relation between fields: distance, relative size, wind direction, etc.
- type and characteristics of used seeds
- environmental characteristics (e.g., background GM pollen pressure),
- use of machinery (e.g., sharing with other farmers)
- target AP

... and *gives recommendations*:

- farming allowed
- farming disallowed
- assess risks (coexistence is possibly achievable)
- assess additional measures (coexistence achievable by small changes)

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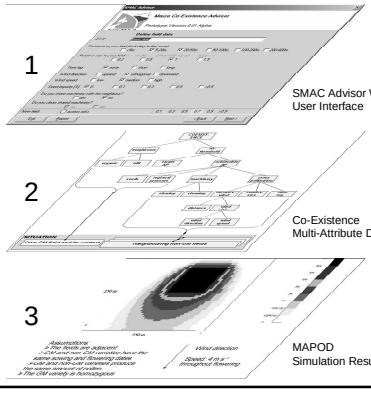
SMAC Advisor Architecture



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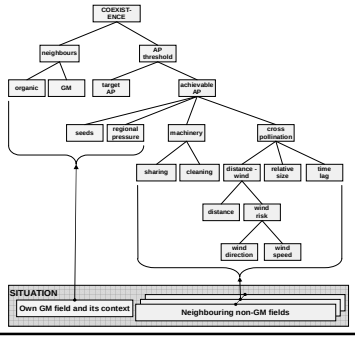
SMAC Advisor Level 2: DEXi Model

Qualitative Multi-Attribute Model



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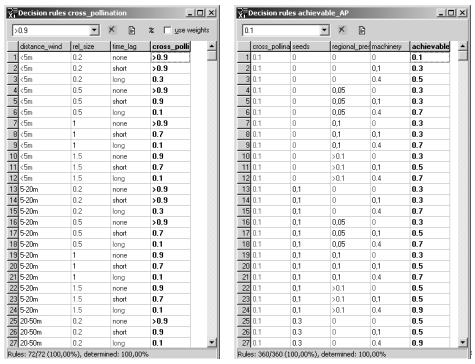
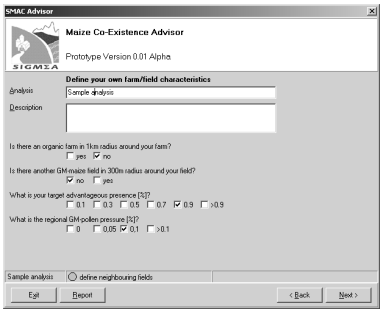
SMAC Advisor Level 2: DEXi Model

Rules



SMAC Advisor Level 1: User Interface



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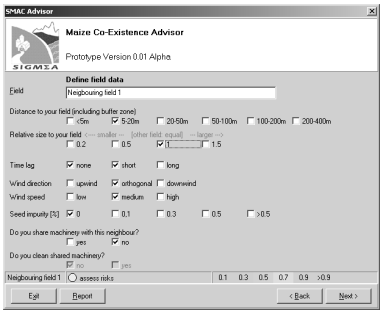
SMAC Advisor Level 1: User Interface



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Summary

1. **Loan Allocation**
2. **Evaluation/Selection of Projects**
3. **Medicine: Risk Assessment**
4. **Evaluation/Selection of Locations**
5. **Advising in Sports**
6. **Application ranking (in Housing)**
7. **Business partner selection (in Housing)**
8. **Assessmentr of Life-Event Portals**

Other areas:

- evaluation of technology (cars, computers, software, Web pages and services, ...)
- evaluation of investment proposals, tenders
- production portfolio evaluation
- performance evaluation of companies
- personnel management
- ...

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