



International “MOKKA” conference

Phytoremediation: Economic aspects

Budapest
June 2007

Theo Thewys, dr.

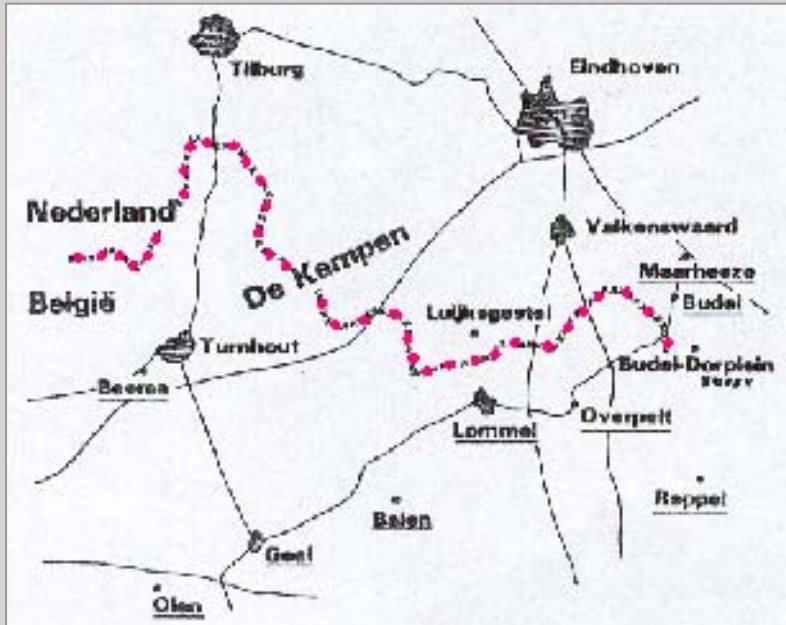
Center for Environmental Studies

Hasselt University, Belgium

www.uhasselt.be/cmkk

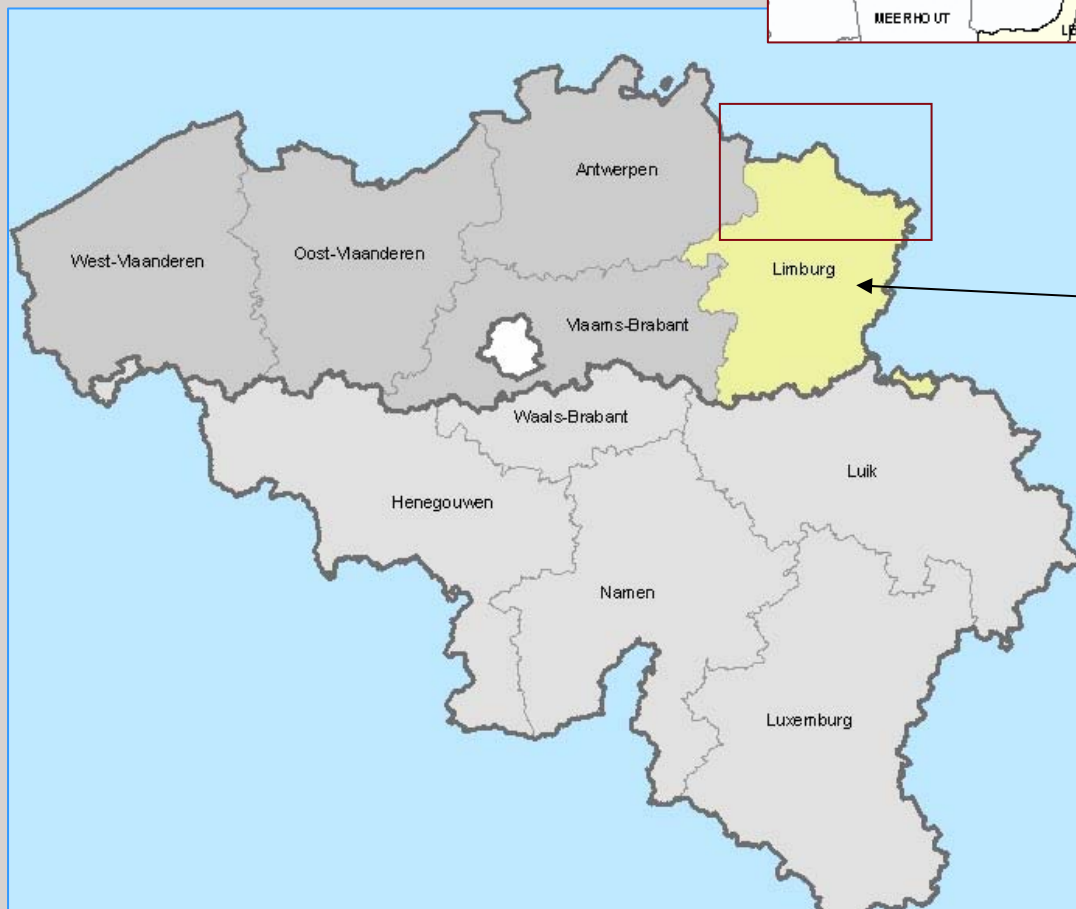


The “Kempen” region:
trans-bordering the Netherlands
and Flanders



- N-eastern part of Belgium, S-eastern Netherlands, 2600 km² or 260.000 ha
- Historical heavy metal pollution (Cd) from zinc smelters
- Soil pollution 3 – 6 – 9 kg/ha Cadmium
- Target: 1.8 kg/ha
- Remediation project ‘durable land management’:
- Soil remediation with the use of plants (“phytoremediation”)
- Collecting the biomass
- Use of the biomass as a cost recovering possibility

Source of renewable energy



Prov. Limburg
in Belgium



Historical pollution from Zinc smelters

Balen

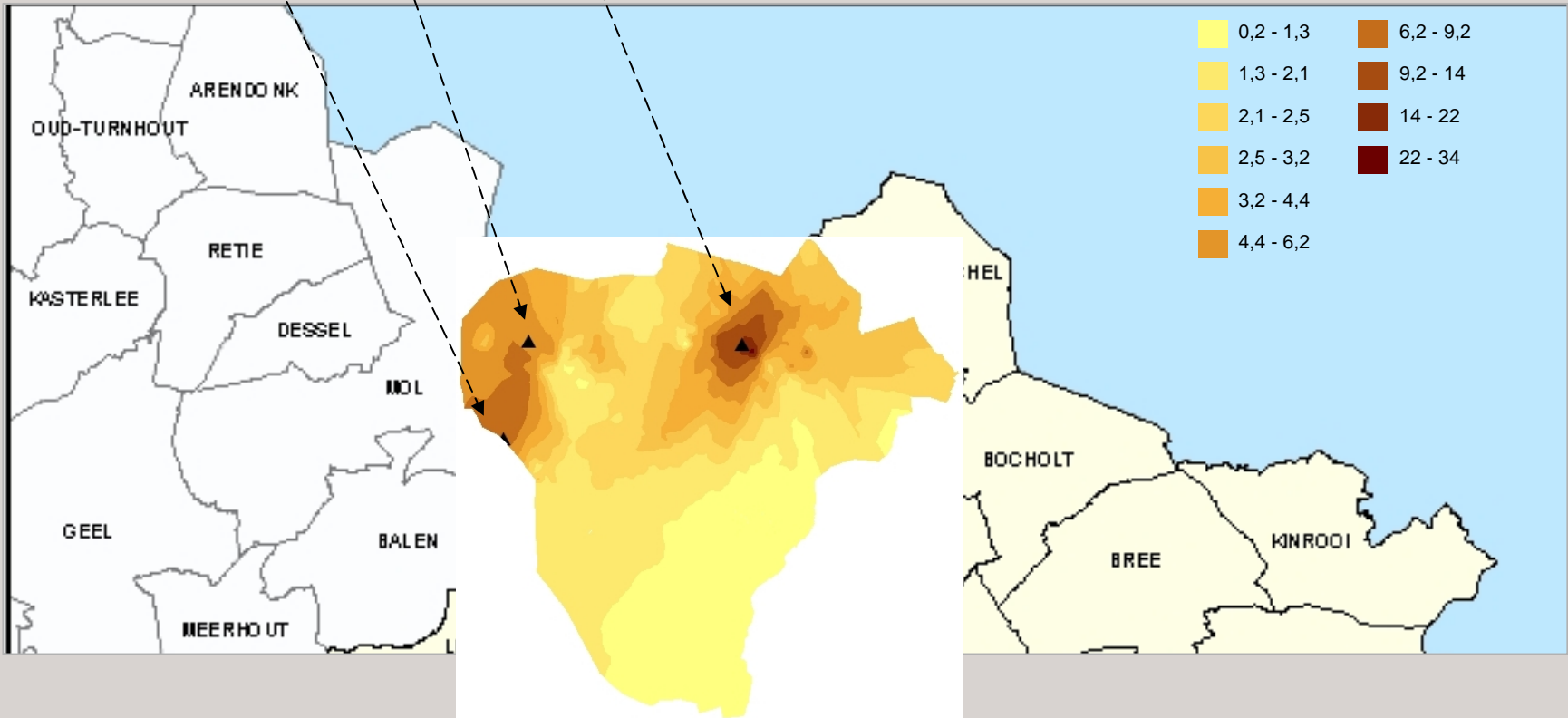
Overpelt

Lommel

Cd mg/kg



Prediction (in mg/kg)
spherical parameters





Data on pollution of soil and crop removal characteristics

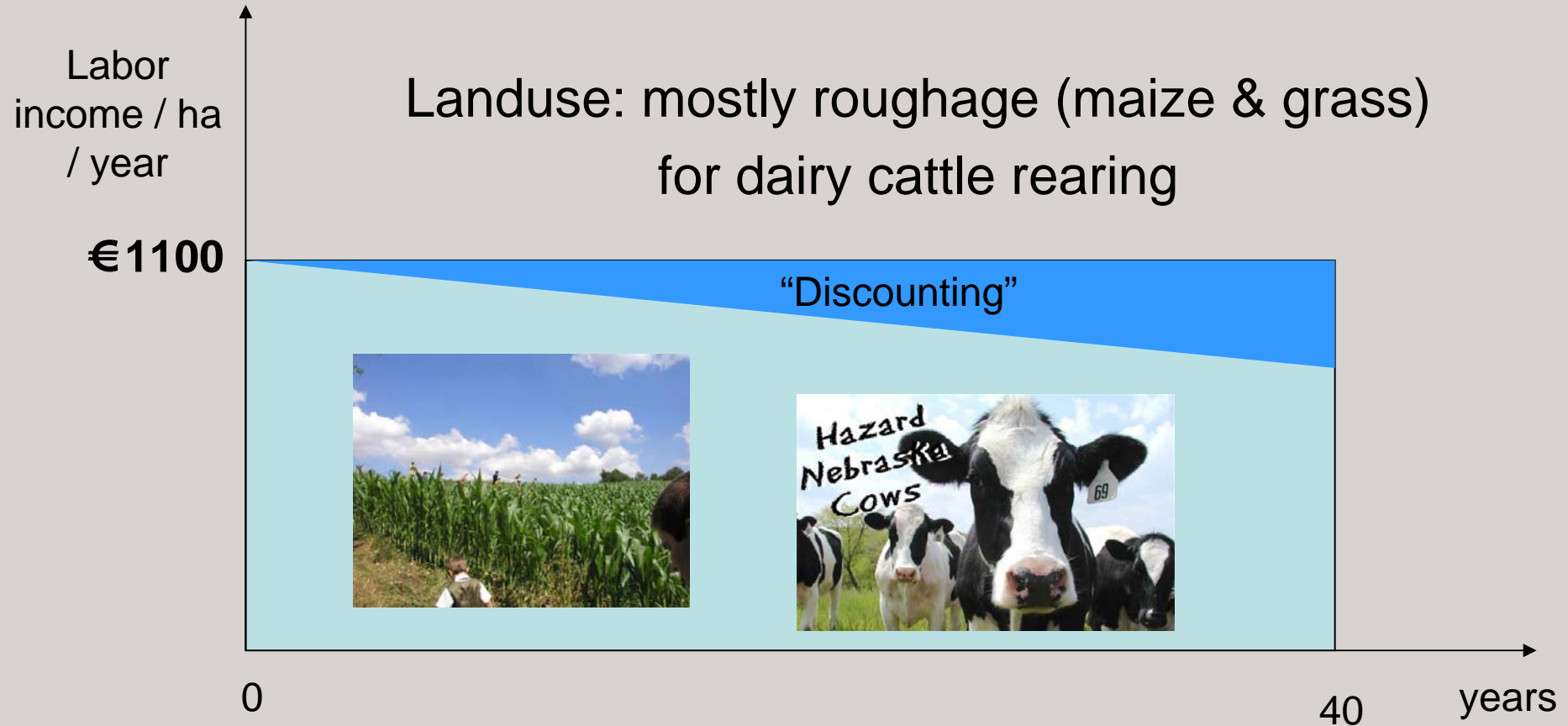
SOIL	Rape	Willow
Target Cd level		
Pollution of soil (kg/ha)	1,8	1,8
Actual pollution		
Depth of soil (m)	0,3	0,5
Pollution of soil (kg/ha)	3,6	6
Removal		
Necessary removal to reach target (kg/ha)	1,8	4,2

	Rape	Willow
Yearly removal Cd (kg/ha)		
Rape	0,07	
Willow stems only		0,144
Willow stems + leaves		0,369
Willow weighted average		0,221



Labor income in current situation

Landuse: mostly roughage (maize & grass)
for dairy cattle rearing



Net Present Value

Labor
income /
ha / yr

€1.100

“Discounting”

(I) Net Present Value of current activity
€680.000 (on 36 ha)

40 years

Labor
income /
ha / yr

€1.100

“Discounting”

Higher labor income in new
cleaned up situation

Labor income
during Reclamation



40 years

(II) Net Present Value ?



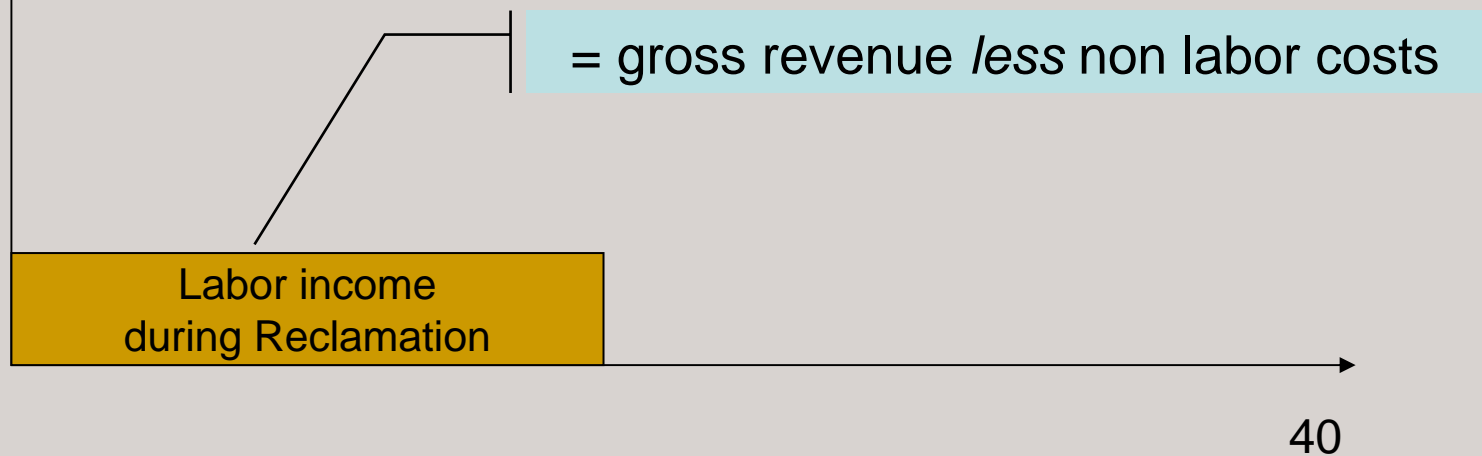
Labor income during reclamation

Labor
income /
ha / yr

(1) **rape** (*brassica nappus*)

(2) **willow** (*salix* spp.) in short rotation forestry

as an energy crop





Use of considered crops

Short rotation coppice

Willow



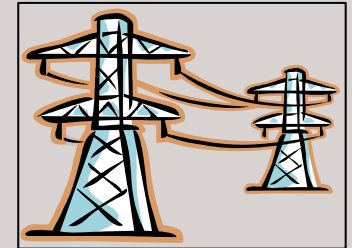
Chips



Co-firing



Electricity



Rapeseed



Biomass

Base material

Biodiesel, bio-ethanol etc.

Pure plant oil



Calculation of yearly income

1 = Total area * **Labor income roughage** / ha

Less 2a (Area Rape + area SRC) * (cost external rough – cost own rough)/ha

2b (Area_Maize_start - Area_Maize_later) * Subs_Maize_pha

Plus 3a Area Rape * **Labor income rape** / ha

3b Area SRC * **Labor income SRC** / ha



Calculation of labor income / ha / year / crop

Labor income roughage

Agricultural survey (dairy cattle): € 1.100/ha/yr

Labor income rape

€ 400 /ha/yr

Rape oil (1.485 lit/ha)

Farmer selling price rape oil (€ 0.5 à € 1)/ lit

Rapeseed Cake (3.015 kg/ha)

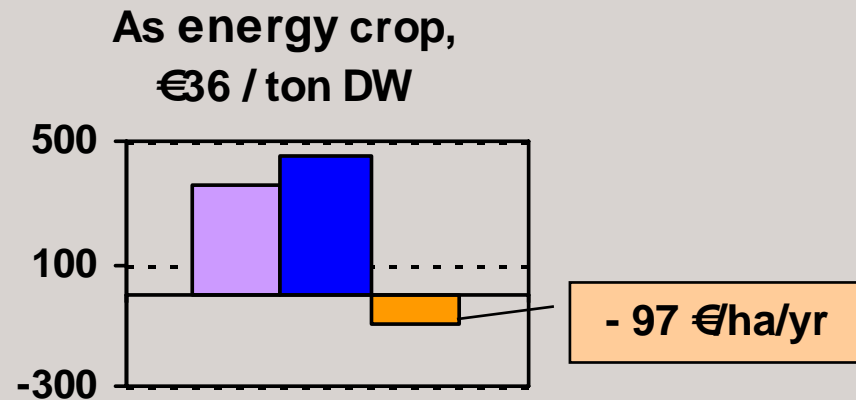
Price rapeseed cake (€ 0.145/ kg)

Subsidy Energy crop non fallow land (€ 365/ha)

Labor income willow as Short Rotation Coppice

Wood: 15 ton /ha; Dry weight: 10 ton/ha

- Gross revenue**
- Non labor costs**
- Labor income**



Cultivation scheme (1)

Start

SRC = 2 ha

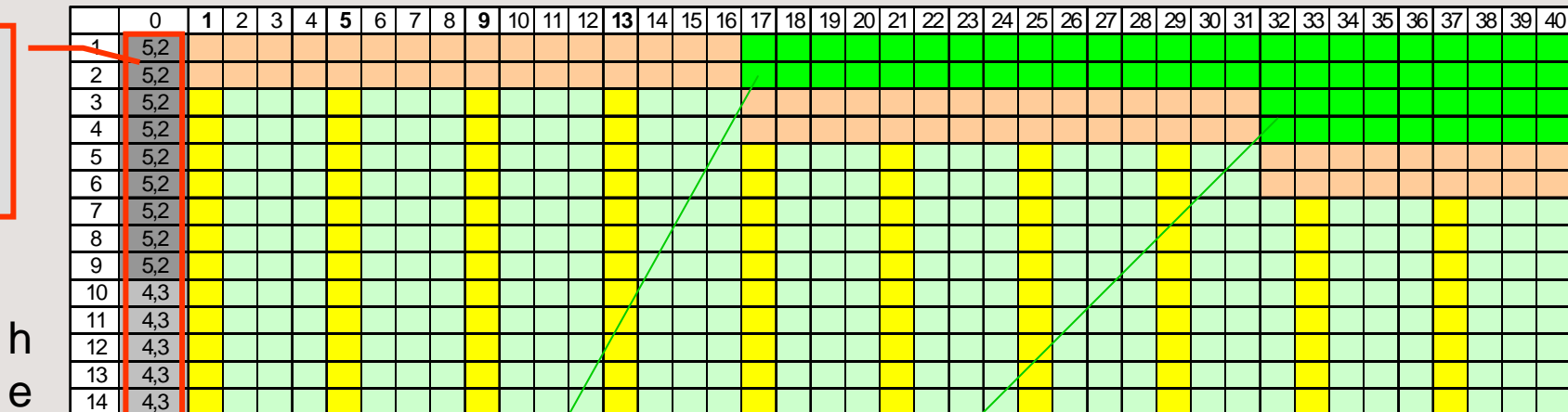
Rape = 16 ha

Roughage = rest

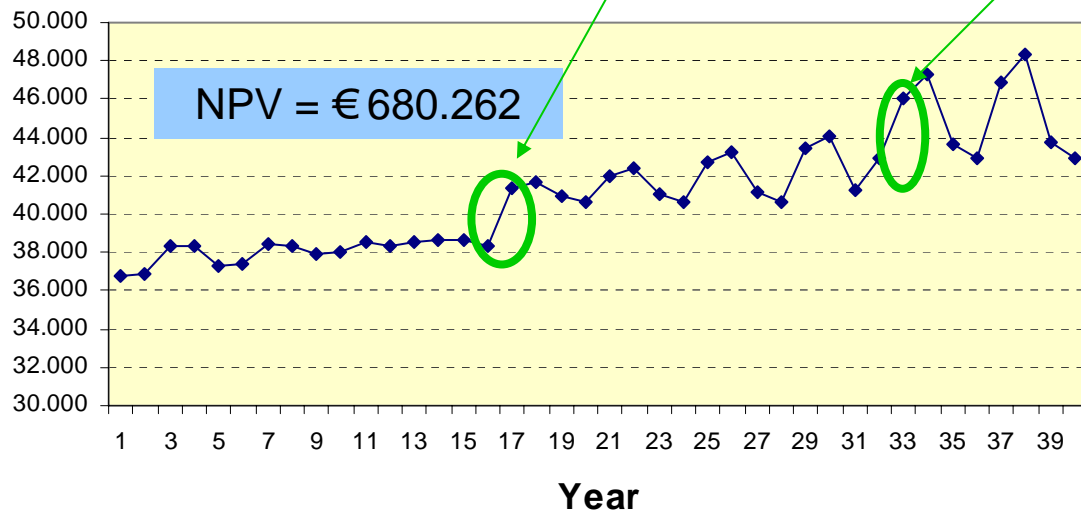
Social acceptance: OK

'Clean'

kg Cd / ha d.m.



Real Income of Labour / year



Cultivation scheme (2)

Start

SRC = 8 ha

Rape = 10 ha

Roughage = rest

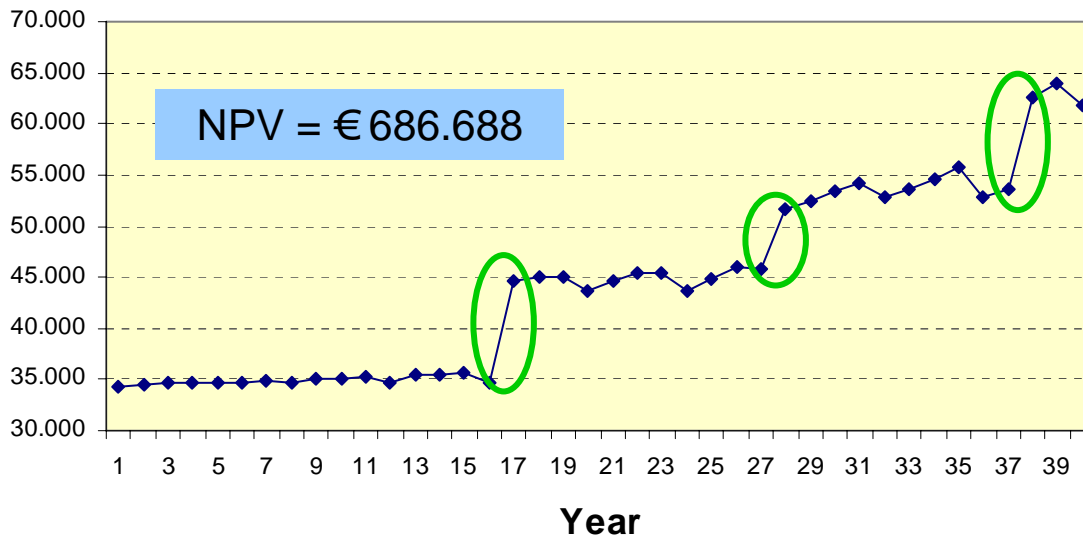
Social acceptance: ?

'Clean'

kg Cd / ha d.m.

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Real Income of Labour / year



Cultivation scheme (3)

Start

SRC = 14 ha

Rape = 4 ha

Roughage = rest

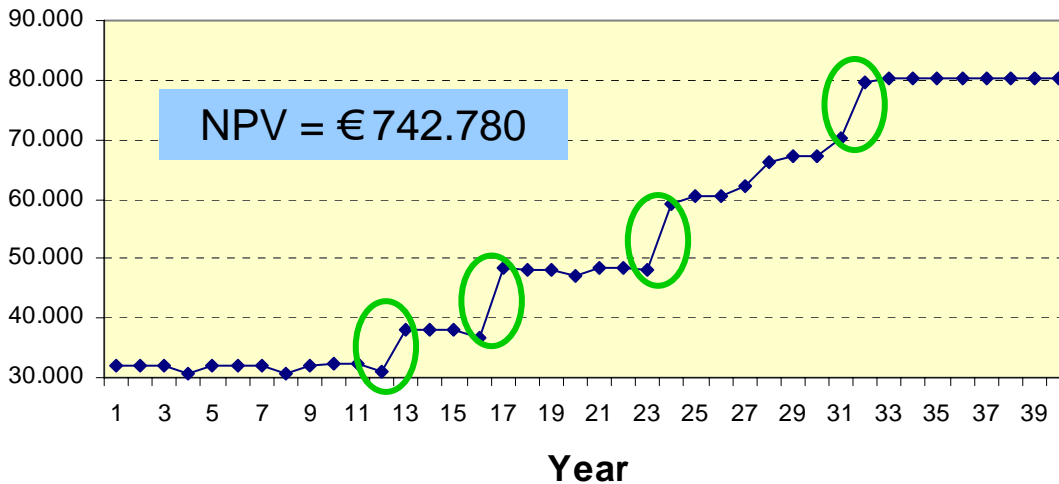
Social acceptance: ??

'Clean'

kg Cd / ha d.m.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
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Real Income of Labour / year

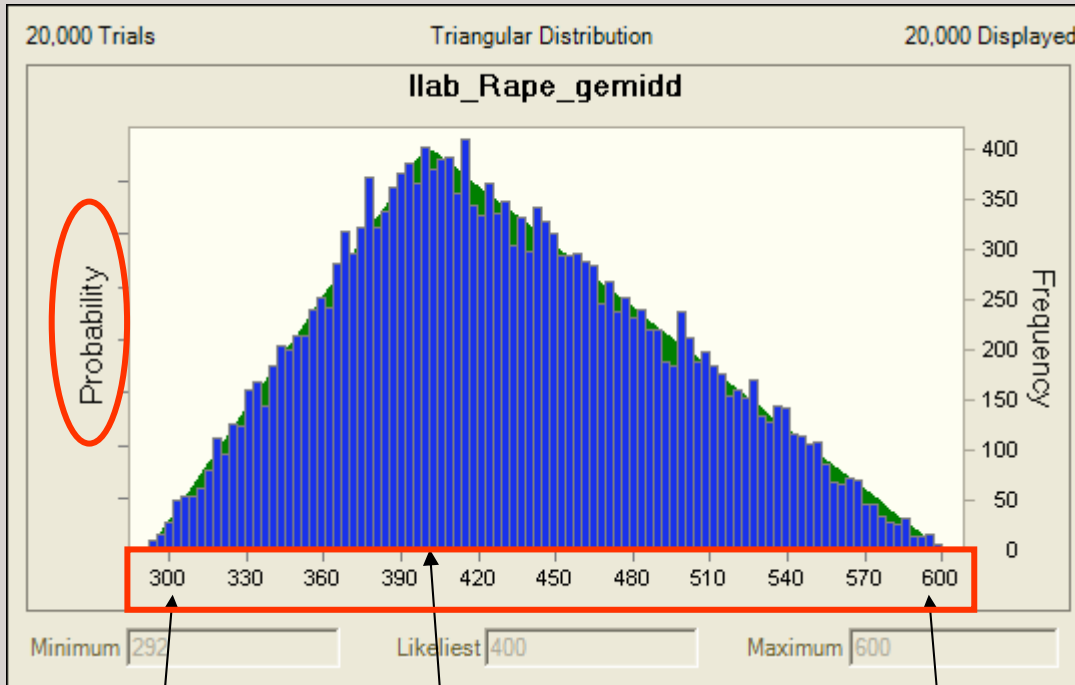




Uncertainty

example: labor income from rape

(€ /ha/yr)



- Assumed triangular distribution
- Values: most likely, min., max.
- 'Monte Carlo' simulations to calculate NPV
- (± 20.000 trials)

minimum

Most likely

maximum

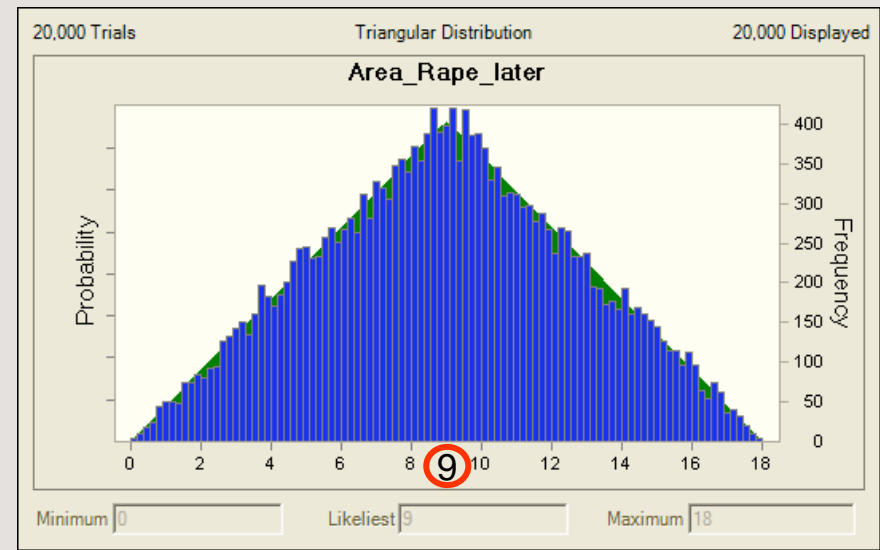


Assumptions: overview

Variable	min.	Like- liest	max.
Labor income rape start (€/ha/yr)	292	400	600
Labor income rape growth ~ price of fossil fuel (%/yr)	+1%	+2%	+4%
Labor income SRC (€/ha/yr)	- 107	- 97	- 46
Labor income growth after remediation (%) (hypot 1)	+0%	+50%	+100%
Labor income growth after remediation (%) (hypot 2)	+100%	+125%	+150%

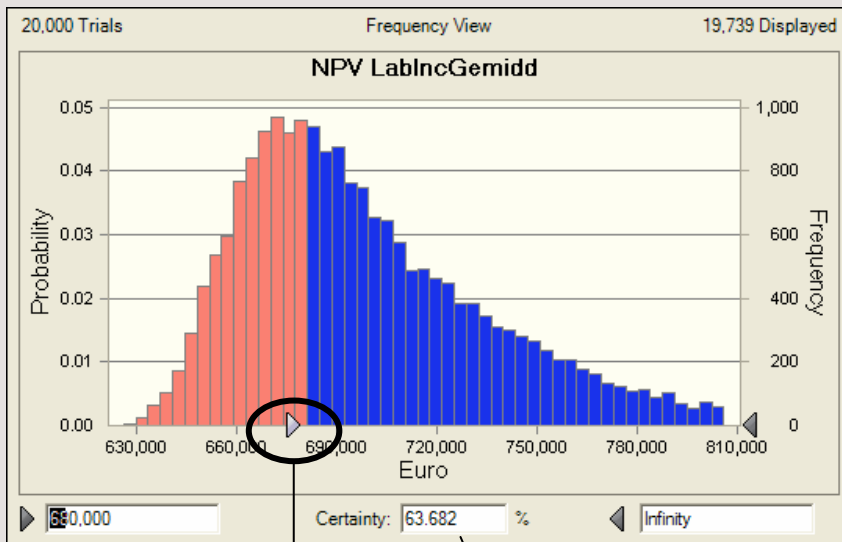
Scenario : (on 36 ha)

1. Rape: 18 – 9 – 0 ha
2. SRC: 0 – 9 – 18 ha
3. Roughage: rest



Labor Income growth after remediation

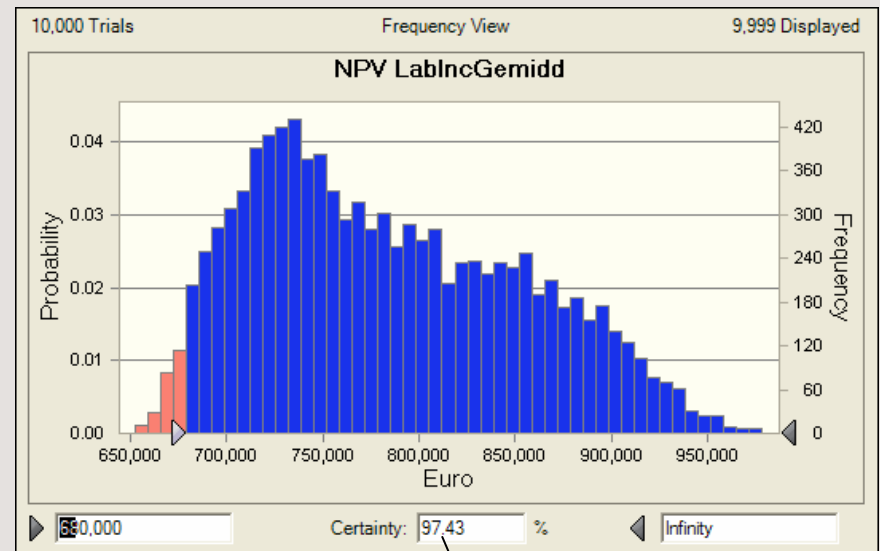
0% - 50% - 100%



NPV current activity: €680.000

Prob: 63.7%

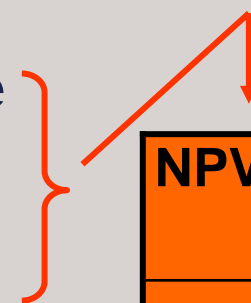
100% - 125% - 150%



Prob: 97.4%

Lower Net Present Value from reclamation => subsidies ?

1. Period: 40 years
2. NPV of actual income
3. NPV of projected income
4. **Annuity** (5%) to recover the difference (over 36 ha)
5. Annuity per ha
6. Annuity per ha as a % of actual yearly income



	(4)	(5)	(6)
NPV diff	Annuity (40 yrs)	Annuity €p ha	Annuity % Inco
20.000	1.166	32	3%
40.000	2.331	65	6%
60.000	3.497	97	9%



Changing important parameters over a range, look at the “influence” of:

- Physical parameters
 - Relative areas of different phytoremediation crops
 - Original soil pollution versus the ‘target’ level
 - Removal rate per year
- Economic parameters
 - Revenue earning capacity of the crops
 - Farmer selling price of rapeseed oil / SRC
 - Future price of fossil oil / SRC
 - Labor income / ha after remediation

Uncertainty → probability of NPV value ?



Thank you

Questions ?

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