An LP-model to analyse economic and ecological sustainability in Dutch dairy farming

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Outline of the presentation

- Background
- General goal
- Sustainability indicators
- Linear Programming-model
- Organization of the analysis
- Results
- Discussion and conclusion

Background

- High interest in sustainability

  - low net farm incomes

  - animal diseases

  - animal welfare

  - environmental problems

- Which dairy farming system is sustainable?

- Make sustainability operational!!

General goal

- Including economic and ecological sustainability indicators in an LP-model
- Use the model to analyse experimental dairy farm "De Marke".

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Economic and ecological indicators

- Economic sustainability

    - net farm income

- Ecological sustainability

    - eutrophication potential per ha

    - nitrate conc. in groundwater

    - water use (m^3/ha)

    - acidification potential per ha

    - global warming potential per 100 kg milk

    - ecotoxicity potential per ha

Nitrogen and Phosphorous cycle

N_2

NH_4

NO_3

P_2O_5

NO_x

NH_3

NO_2
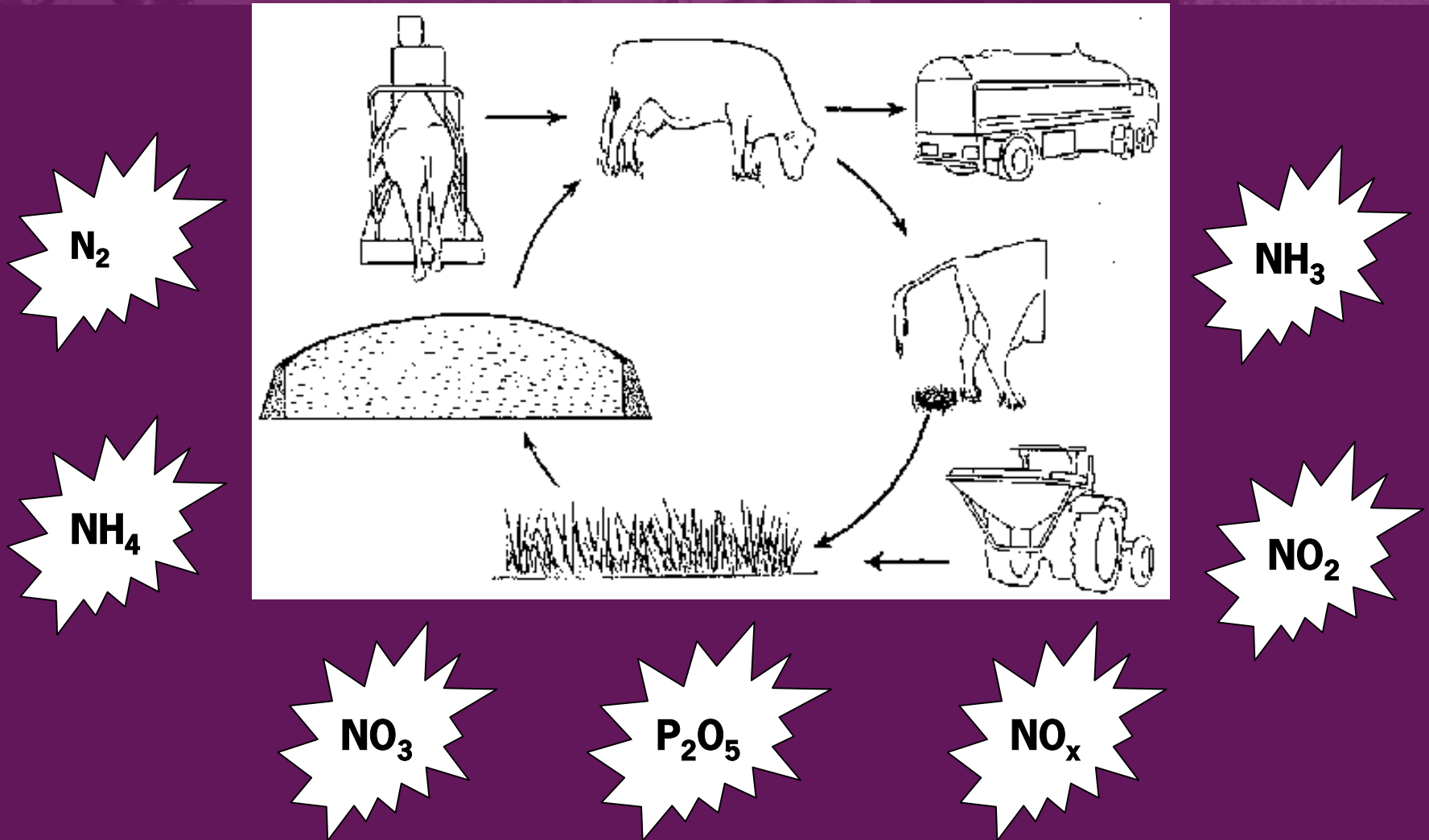
Linear Programming model

- Activities and constraints

  - grass production

  - maize production

  - family labour

  - environmental policy

- Net farm income is maximised

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Organisation of the analysis

- situation *without* environmental legislation and *without* measures applied at "De Marke" (**"Basis"**)

- situation *with* environmental legislation and *without* measures applied at "De Marke" (**"Policy 2004"**)

- situation *with* environmental legislation and *with* particular measures applied at "De Marke" (**"De Marke 2004"**)

Environmental legislation

- Farm input and output determine surplus
- Surplus is expressed per ha and compared with the acceptable surplus

Acceptable surpluses (kg/ha):	Phosphate	Nitrogen
grassland	20[a]	140
arable land	25[a]	60
Levies €/kg	9	2.30

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Experimental farm "De Marke"

- Goals   - reduce nutrient losses

                - maintain economic sustainability

- Environmental measures

                - livestock number and crop rotation

                - fertilisation and feeding

                - barn

Starting points

Farm structure	Unit	Basis/ Policy 2004	De Marke 2004
Area	(ha)	55	55
Milk quota	(* 10^3 kg)	658,480	658,480
Milk production	(kg per cow)	8760	9080
Fat	(%)	4.36	4.28
Protein	(%)	3.44	3.48
Replacement rate	(%)	38.0	33.0
Grazing cows	hours/year	2196	600
Grazing young stock	hours/year	5832	2880

Technical results

	Basis	Policy 2004	De Marke 2004
Land use:			
- Grassland (ha)	32.7	33.9	22.1
- N level grassland (kg mineral N)	360	199	250
- Maize (ha)	11.5	15.3	20.2
- Maize sold(ha)	6.9	3.1	0.0
- Ground maize ear silage (ha)	0.0	0.0	6.7
- Triticale (ha)	3.9	2.7	5.9
By-products purchased (1 GJ NEL)	24.8	24.6	36.2
Concentrates purchased (1 GJ NEL)	144.8	153.4	51.4

Economic results

	Basis	Policy 2004	De Marke 2004
Gross revenues	257,167	253,477	249,357
Costs	221,390	220,186	230,717
Net farm income	**35,777**	**33,291**	**18,640**

Major change in costs:

- purchased feed	29,794	32,439	19,364
- fertilizers	8,874	5,809	3,753
- contract work	30,105	28,612	46,464

Environmental results

	Basis	Policy 2004	De Marke 2004
Nitrogen input (kg N/ha)	275.1	209.8	158.6
Nitrogen output (kg N/ha)	91.0	80.7	72.0
Nitrogen losses (kg N/ha)	**163.1**	**109.3**	**57.1**
Acceptable surplus (kg N/ha)	-	109.3	92.2
Phosphate input (kg P_2O_5/ha)	29.2	35.1	19.5
Phosphate output (kg P_2O_5/ha)	36.0	32.8	30.0
Phosphate losses (kg P_2O_5/ha)	**-6.8**	**2.3**	**-10.5**
Acceptable surplus (kg P_2O_5/ha)	-	21.9	23.0

Ecological sustainability

Indicator	Basis	Policy 2004	De Marke 2004
Eutrophication potential per ha (NO_3^- eq.)	858	711	421
Nitrate concentration in groundwater (NO_3^- mg)	119	79	68
Water use per ha (m^3)	3614	3318	3488
Acidification potential per ha (SO_2 eq.)	92	79	74
Global warming potential per 100 kg milk (CO_2 eq.)	787	742	684
Aquatic ecotoxicity potential per ha (1,4-DCB eq.)	3907	3915	2624
Terrestrial ecotoxicity potential per ha (1,4-DCB eq.)	151	153	103

Discussion

- Model valid   - logical results
  - comparison with actual data

- Direct environmental impact
- Chain indicators (LCA)

Conclusion

- Environmental policy effective tool
- "De Marke" highest in ecological sustainability
- Model can be used to compare different farming systems on sustainability
- Model can be used to evaluate environmental policy on economic and ecological indicators

- Further research focuses on including social sustainability