Global economics of nutrient cycling

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Contents

- What is meant?
- Requirements and sources of nutrients for humans
- Land for people, food crops and fodder crops
- Environmental and economical bottlenecks
- Nutrient recycling and use efficiency
- Conclusions

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Outline: what do we mean by

- Global
- Nutrients
- Economics
- Cycling

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Global

- General: theoretical approach
  simplified: food and fodder crops
  nitrogen
- World wide: no specific regional cases
  world wide nutrient cycling
  international trade

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Nutrients

For	Specification	Source
Humans	Energy, protein, fats, etc.	Crops Animals
Animals	Energy, protein, fats, etc.	Crops Household leavings
Crops	N, P, K, etc.	Soil Manure Chemical fertilizers Compost, sewage

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Economics implies there is

Demand	driven by consumers, to satisfy needs
Supply	driven by suppliers, to gain income, economics of scale and specialization
Price	free prices, determined by interplay of demand and supply
	fixed prices, determined by : -- governments -- monopolies

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Cycling of nutrients

- By nature
- *Ecosystem service*, for free
- Critical to functioning of the earth
- Produces human welfare
- Interdependent
- Worldwide
- Global economic value: 17 * 10^{12} US$ per yr

- By men
- Past: people follow nutrients
- Present: nutrients follow people
- Future: recycling of nutrients
- Soils, fertilizers and manure
- Market and environment
- Local and worldwide
- Value fertilizers: 0.1*10^{12} US$ per yr

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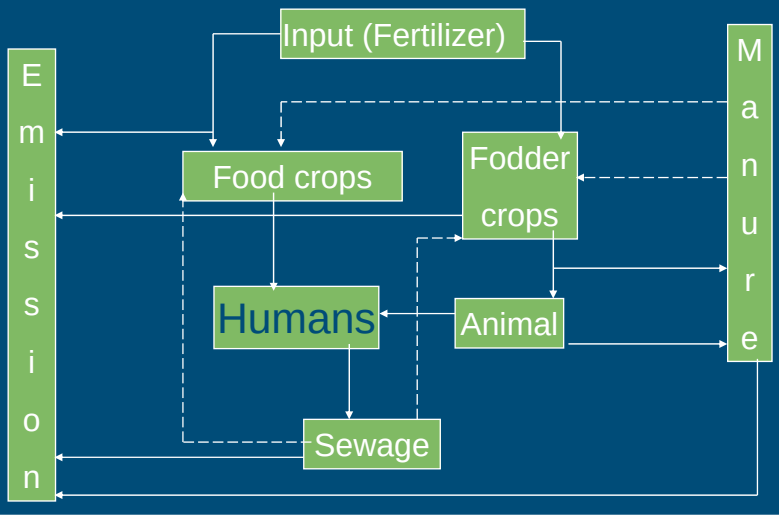
Nutrient flows and recycling (dashed)



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Nutrient requirements

for adult males and for 'average persons'

	Adult male	Average person
Energy, kcal per day	2800	2000
Protein, g per day	70	50
Fat, g per day	45	35

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Required food N and fodder N production

per average person, kg per year

Required N	3.0
Subdivision of food from plant and animal products is critical for environmental problems!	
Food crops	1.5
Meat	0.75
Milk	0.75
Fodder N for meat N, kg and kg/kg	11.25, and 15
Fodder N for milk N, kg and kg/kg	1.875, and 2.5

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Minimum required land area per average person

	Area, ha	
	Standard	Vegetarian
For fodder crops	0.08	0
For food crops	0.01	0.02
City infrastructure (10 000/sq km)	0.01	0.01
Total required area (rounded)	0.1	0.03

Or three to four times as much

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Dimensions 10 million city and surroundings

	City	City + food crops	City + food + fodder crops
Area, sq km	1000	2000	10000
Diameter, km	36	50	113
Square side, km	32	45	100
Max. distance to centre, km	22	32	71

- What is the problem?

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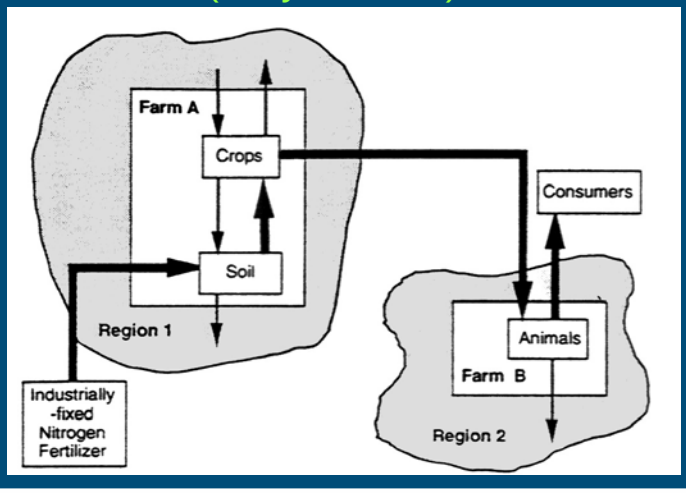
Spatial separation of fodder crops and animals (Lanyon, 1995)



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Problems

- High land price around city
- Low net return to fodder production
- Farmers have to move from city, especially for fodder crops
- Long transport distances for feedstuffs, animal products and manure
- Environmental pollution

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Relative transportation costs

(Oenema and Tamminga, 2005)

	Transportation costs
Feed	1
Live animals	3 - 5
Animal products	1.5 – 2.5
Manure	20 - 30

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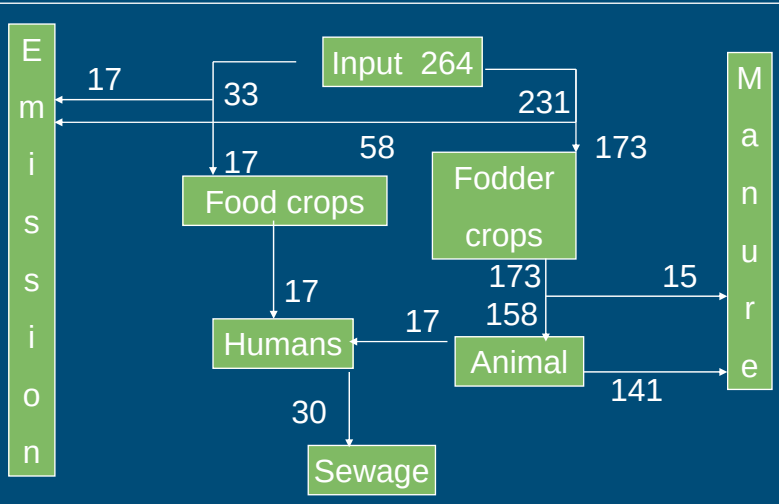
N flows (kg per ha per year); standard high efficiency, no recycling



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N destination under standard high efficiency

kg N per ha of food and fodder crops per year

External inputs (fertilizer)	264
Direct emissions	75
Manure	156
Sewage	30
Output = potential environmental burden	261
Human consumption	34 (13 % of input)

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Environmental burden

- Environmental problems arise when livestock industry and fodder crop land are far apart
- Food crop area is far too small to absorb all manure
- Ecosystem of livestock area will collapse sooner or later

- Repair holes through which nutrients leak to environment
- Recycle sewage and manure nutrients to fodder crop land
- Keep animals in area with fodder crops

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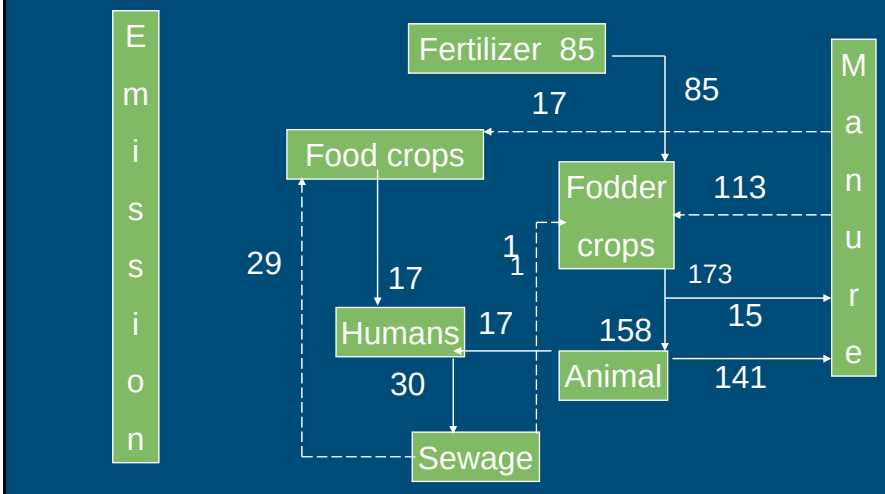
N flows (kg per ha per year); maximum efficiency and recycling



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Required input N (% of standard 264 kg)

as affected by nutrient use efficiency and recycling

	Efficiency	
	Standard high	Maximum
No recycling	100	67
Compost and manure (40, 65 % of N need) to food crops only	93	61
All compost and manure to food and fodder crops	66	32

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Some other contributions

- Increase nutrient use efficiency of animals
- Redirect diet from beef via sheep, pork, and chicken to fish (and vegetarian)
- Convert manure and sewage sludge into less bulky fertilizers to facilitate recycling
- Use technological know-how and commercial infrastructure of fertilizer industry for this

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Responsibilities and measures

Who is responsible?	Some possible measures
Consumer	Create awareness
Farmer	Restrict number of animals Apply manure on land of other farms
Fertilizer industry	Start recycling of manure to ▪compensate for reduced fertilizer sales ▪minimize needless fertilizer application
Government	Buy out farmers and help to migrate

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Major conclusions and statements

- Livestock and meat industries are best situated in areas used for fodder and non-food crops
- Recycling of nutrients and improving NUE strongly reduce
  - environmental burden
  - needs of fertilizers
- Fertilizer industry is challenged to partly shift from fixing and mining of nutrients to recycling of nutrients

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