COST ACTION 869 / Workshop WG 3:
Intercomparison of the first RBMP of the European member states
regarding implementation of measures to reduce nutrient losses from rural areas"
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Actual and future needed contributions of Sciences and Policy in Germany regarding the implementation not only of the RBMP of the EU-WFD for reducing impact of agricultural losses of the nutrients C, N, P, (S) in river basins / catchments

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A) INTRODUCTION

From all human activities the activity "Nutrition" of agriculture, human nutrition as well as corresponding waste and wastewater management have the most comprehensive impact on environmental damages and threatening human health both in the EU-27 and e.g. in Germany. In Germany with contributions between 26 and 90% (esp. eutrophication) and those of animal consumption and production between 70 and 90% respectively (**Tab. 1**). The EU-WFD (2000) aims the P reduction in surface waters and groundwater, but N reduction together with the EU-Nitrates Directive (1991) and the EU-Groundwater-Directive (2003) only in respect to human health (Methaemoglobinaemia, stomach cancer) with an supposed critical level of 50 mg $NO_3^{-.}$ l^{-1}. **But nitrate preserves, rather than threatens human health** (e.g. against bacterial infections by dental caries, gastroenteritis, cardiac infection, cardiac vascular disease, hypertension of blood pressure and gastric ulcers) with needed daily adult intakes of 250-1400 mg NO_3^{-} d^{-1}. **(Tab. 2+3)** Furthermore critical N and P loads esp. for coastal and marine waters are more or less neglected, because the impact of the WFD ends only 1 sea mile away from the costal lines. Those dilution strategies like here against eutrophication of coastal and marine waters will fail without critical loads and levels concepts. But now both the EU and National German Marine Stratety (2008) aim good chemical status (also nutrients) in coastal waters at least within the zone of 12 sea miles from the coastal lines.

A) METHODS, MAIN RESULTS AND CONCLUSIONS

As described in COST 869 with about 100 fact sheets there exist also in Germany similar numerous proposals from sciences and advisory groups to reduce N and P emissions from rural areas to groundwater and surface waters. Since 1983/87 till 1998/2000 the **nutrient inputs from agriculture into the surface waters** has decreased related to N only of about -20% and to P has even increased by +4% **(Tab. 4)**. The shares of agricultural sources in 1998/2000 on total N inputs were 57%, on total P inputs 50% (Behrendt et al. 2003).

The average maximum tolerable critical nutrient levels and loads of the streams are only about 2fold higher than their (natural) background (BG) values. This is corresponding in Germany to 2x CBG_N = 1.42 mg $TN \cdot l^{-1}$ and 2x IBG_N = 186 740 t $TN \cdot yr^{-1}$ respectively and 2x CBG_P = 0.068 mg $TP \cdot l^{-1}$ and 2x IBG_P = 7 156 t $TP \cdot yr^{-1}$ respectively (LAWA 1998, Behrendt et al. 2003) **(Tab. 5)**. **Based on the critical N and P levels and corresponding loads, there is a need for further input reductions** in total of -73% and -78%, from agriculture of -90% and -90% and ever from other point and diffuse sources of -88% and -88% respectively (**Tab. 4).** Since 1998/2000 these N and P inputs into the groundwater and surface waters by agriculture were absolutely more or less the same (German EPA 2000-2008).

The main causes of missing (further) effective reductions in N and P emissions from agriculture and to get developments towards sustainable nutrient balances not only of agriculture but also of the total system nutrition (including also human nutrition) were on the one hand intentional misleading official recommendations esp. in respect to the optimum use of organic fertilizers (esp. animal manure) since the 80ties of the former century to install and maintain a more than 2fold too high animal production (maximum 0.1 $AU \cdot capita^{-1}$) and up to 4fold too high animal densities (maximum 1.0 $AU \cdot ha^{-1}$).

Since these 80ties it is well known that **the main potential for P loss mitigation and preserve mineral P resources is to maintain soils at or near the lowest mean soil test P (STP) level compatible with good**

plant production and match inputs with outputs by yield (Fig. 1). **But actually there exists in Germany a P-paradoxon**: While advisers responsible for sustainable nutrient balances and to themselves give the P recommendations according to the long-lasting basic findings both for mineral and organic P (**Tab. 6, green left site**). Other advisers accept this only for mineral P and recommend P inputs by organic P according to **Tab. 6, red right site** or even according to the German Fertilizing Directive with a P input according to P output plus bonus 20 kg $P_2O_5 \cdot ha^{-1} \cdot yr^{-1}$ on soils in optimum and even in hypertrophied conditions. **Therefore on the other hand corresponding agricultural legislation like the German Fertilising Directives (1996-2007**) mainly made by the German Ministry for Nutrition, Agriculture and Consumer Protection dominated by Lobby ➔ Lobbyism (➔ Corruption) of e.g. these officials, farmers organizations, nutrition involved industries and research associations, etc. **maintain these actual non sustainable nutrient balances, esp. of C, N, P (Tab. 7). Tab. 8 shows these preventing forces in the development / implementation of a sustainable nutrition system e.g. in Germany**. Additionally actual **N surplus of German agriculture** increases from 106 kg $N \cdot ha^{-1} \cdot yr^{-1}$ in 2001/2003 to 159 kg $N \cdot ha^{-1} \cdot yr^{-1}$considering not only N inputs but also the N deliveries by additional atmospheric deposition (+13 kg $N \cdot ha^{-1} \cdot yr^{-1}$) and esp. by net mineralization through change from grassland to arable land (+29 kg $N \cdot ha^{-1} \cdot yr^{-1}$) and cultivation of moor land/fens (+11 kg $N \cdot ha^{-1} \cdot yr^{-1}$) (**Tab. 9**). The production of biomass (esp. bioenergy) will furthermore increase N and P surpluses of agriculture.

But there are also needs and corresponding **(inter-)national and worldwide perspectives in the development of sustainable nutrient balances, not only sectional within agriculture but by a holistic approach for the total systems like here multi-sectional and multi-medium scaled C-, N-, (P-), S-balances for the systems nutrition and biomass (esp. bioenergy)**. Initiated by Agenda 21 of Rio (1992) and enforced by the EU Strategy for Sustainable Development (2001/2005) Germany starts with a “National Strategy for Sustainability as Perspectives (2002)” and “The Report on Sustainability Indicators (2008)” referring 8 of 21 indicators for “Sustainable Land and Soil Use”. **One indicator is an** unrealistic **N surplus for agriculture (farm gate balance)** in 2010 of 80 kg $N \cdot ha^{-1} \cdot yr^{-1}$ but a realistic one **of 50 kg** $\mathbf{N \cdot ha^{-1} \cdot yr^{-1}}$

latest in 2020. The last one is based on the one hand on the critical levels and loads of N for all environmental spheres (Isermann, EUROSOIL 2008) and on the other hand on a healthy human nutrition especially in respect to animal food and only corresponding food production (**Tab. 9**). Correspondingly German EPA developed a multi-medium and multi-system strategy for those needed reductions of N emissions (2008). EUROSOIL (2008) shows about 500 indicators referring to sustainable land and soil use, especially in respect to the 11 main threats on soils, 10 of these are essentially caused by agriculture and 5 by their emissions of C, N, P, S.

There is a general agreement that without the optimization of humus (C) balances in agriculture there is also no optimization of N, P and S balances with the nutrition and biomass systems (Tab. 10). This should also be accepted by COST 869.

The political implementation of those sustainable C-, N-, P-, S-balances of the total system nutrition should be made by the following essential measures:

1. Nutrient surplus taxes and monetary awards according to nutrient surpluses higher of lower than the tolerated N surplus
2. VAT of 19% instead of actually 7% and pay back these taxes (about 24 milliards € $\cdot$ yr^{-1}) or only the difference (about 15 milliards € $\cdot$ yr^{-1}) back to agriculture
3. Therefore no further need for subsidies (2006: 6.4 (Germany) + 6.5 (EU) = 12.9 milliards € $\cdot$ yr^{-1}
4. Based on quotas for production there is a potential of 120 milliards € $\cdot$ yr^{-1} of saved illness costs by over-nutrition and saved costs to restore the environment in similar amounts are more than enough to give the farmers fair prices for their products.

Partly initiated by BSNLC Tab. 12-16 show "(Inter-)national initiatives for Sustainable Land Use for Nutrition and Biomass (~energy) systems: A perspective and challenge both for policy and sciences as fundamental parts of (inter-)national strategies for sustainability".

Tab. 1: Contribution of:

1. **the total system nutrition (agriculture with plant and animal production, human nutrition with plant and animal food consumption as well as waste and waste water management)**
2. **animal production and animal food consumption within the system nutrition**

to environmental changes / damages and threatening of human health in Germany

	% contribution	
	1. Total system nutrition	2. Animal production and consumption within the system nutrition
1. Eutrophication	80	70
2. Acidification	40	90
3. Climate change	27	60- 80
4. Decline of biosphere (also consequences of 1.-3.)	80	70
5. Threatening human health (Untimely death)	78	80

Re0931

Tab. 2: Nitrate not threatens but preserves human health

Activities / Symptoms	Concentrations [$mg \cdot l^{-1}$]	Nitrate ingested [$mg \cdot person^{-1} \cdot d^{-1}$]	References
A) Questionable medical evidence to threaten human health **1. Methaemoglobinaemia ("Blue Baby syndrom"): Stimulated by bacterial gastroenteritis caused not by nitrate but by nitric oxide (NO)**	**Drinking water (without justification):** **EU: < 50 mg $\cdot$ l^{-1}** **USA: < 44 mg $\cdot$ l^{-1}** **no effects / impacts with > 0 up to 1200 mg $\cdot$ l^{-1}**	**with 2.5 l $\cdot$ $person^{-1} \cdot d^{-1}$:** **< 125** **< 110** **no effects / impacts of 175 – 700 mg $\cdot$ d^{-1} to infants or older people**	**WHO (1970)** **Addiscott and Benjamin (2004)**
2. Stomage cancer	**Absence of any link between stomage cancer and nitrate shown by epidemiological studies**		Addiscott and Benjamin (2004) EPIC-Study (1992-2004)
➔ Evidently causes of cancer (%)	1. **Unhealthy life style:** **63** a) **(over) nutrition** **30** b) smoking 30 c) alcohol 3 2. Infections 15 3. Other causes 13 (e.g.medicins, radiation, immune-suppressions) 4. Professional exposition 5 5. Inheritance 4		EPIC-Study (1992 – 2004) (European Prospective Investigation into Cancer and Nutrition)

Re1024a

Tab. 3: Nitrate not threatens but preserves human health

Activities / Symptoms	Concentrations [mg · l^{-1}]	Nitrate ingested [mg · $person^{-1}$ ·d^{-}]	References
A) Nitrate preserves human health acting against: 1. Gastroenteritis caused by Salmonella and Escheria coli	a) Tongue: NO_3 ➔ NO_2^- (nitrite) (3-30 mg NO_2 · l^{-1} in salvia) b) Stomage: $NO_2^- + H^+$ ➔ HNO_2 (nitrous acid) HNO_2 ➔ NO (nitric oxide) + NO_2 (nitrogen dioxide)		Addiscott and Benjamin (2004)
2. Dental caries and skin pathogens (Tinea pedis)	Adding nitrate or nitrate to stored meat to protect against botulism		Addiscott and Benjamin (2004)
3. Repression of nitrate and nitrite of cardiac infection and reduction of cardiac infarct as well as cardiovascular disease (mice fed esperiments)	50 mg NO_2^- · l^{-1} up to 1000 mg NO_3 · l^{-1}	- -	Bryan et al (2007)
4. Hypertension: Repression of blood pressure (human experiments)	500 ml red beetroot juice with 2100 – 2790 mg NO_3 · l^{-1}	1050 – 1395 mg NO_3 · l^{-1} · d^{-1}	Webb et al (2008)
5. Repression of gastric ulcers by fruits and vegetable rich in nitrate (human experiments)	200 – 300 g of nitrate rich vegetables with > 1000 mg NO_3 · kg^{-1} Reactions: see gastroenteritis (B 1.)	> 250 mg NO_3 · d^{-1}	Petersson (2008)

Re1024b

Tab. 4 :Nitrogen (N) and Phosphorus (P) inputs into the surface waters of Germany in Ø 1983/ 87 and Ø 1998 / 2000 (H.Behrendt et al. 2003) and needed further input reductions according to the critical N and P loads corresponding to 2fold background values of running waters respectively [EU-WFD-2000, -Groundwater Directive – 2006 and especially –Marine Strategy-2008]

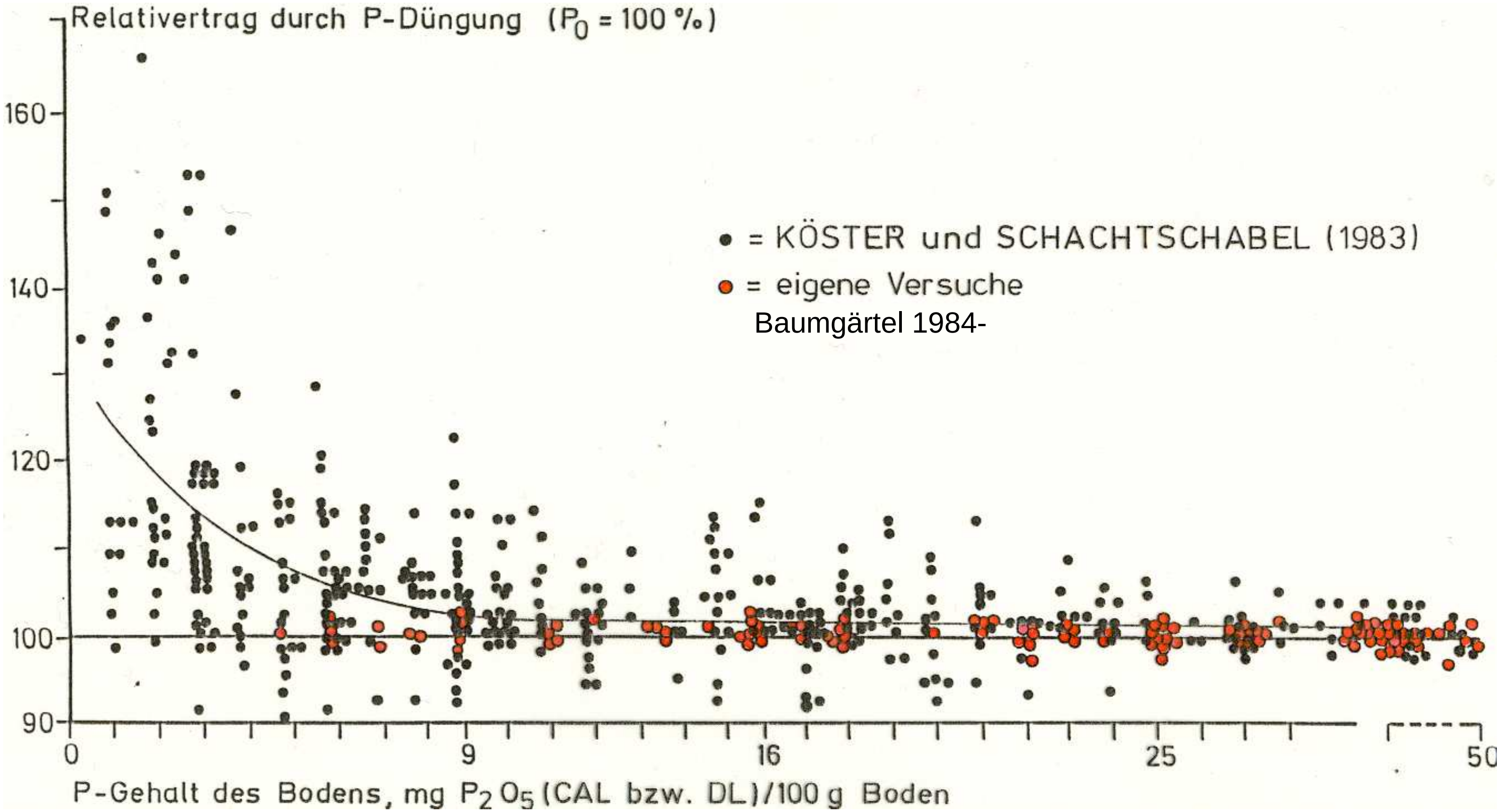
Agricultural area (aa): **1985: 18.2 Mio ha** **1999: 16.3 Mio ha**	**Nitrogen [$t \cdot yr^{-1}$]**		**Phosphorus [$t \cdot yr^{-1}$]**	
	Ø 1983 / 87	**Ø 1998 / 2000**	**Ø 1983 / 87**	**Ø 1998 / 2000**
1. Total input **(% change)**	(100) 1 088 050 (5.8) -	(100) 687 970 (3.7) -37	(100) 91 780 (12.8) -	(100) 33 163 (4.6) -64
2. of it: **2.1 Anthropogenic input** **(% change)** **2.1.1 Agriculture** **[$kg \cdot ha\ aa^{-1} \cdot yr^{-1}$]** **(% change)** **2.1.2 Other sources** **(point + diffuse)** **(% change)**	 (90) 982 670 (5.2) - **(45) 487 810 (2.6)** **26.8** **-** (45) 494 860 (2.6) -	 (82) 561 220 (3.0) -43 **(57) 390 040 (2.1)** **(23.9)** **-20** (25) 171 180 (0.9) -65	 (97) 89 316 (12.5) - **(17) 16 049 (2.2)** **(0.88)** **-** (80) 73 267 (10.2) -	 (88) 29 304 (4.1) -67 **(50) 16 698 (2.3)** **(1.0)** **+4** (38) 12 606 (1.8) -83
2.2 Background (IBG) **(Ø 1993/ 97)**	(9) 93 370	(14) 93 370	(4) 3 578	(11) 3 578
3. Critical loads = 2 x IBG	(17) 186 740 (1)	(27) 186 740 (1)	(8) 7 156 (1)	(22) 7 156 (1)
4. Needed further reductions **of total input (1 minus 3)** **(% change)** **of it:** **4.1 Agriculture** **(% change)** **4.2 Other sources** **Point + diffuse)** **(% change)**	-901 310 -83 **n.d.** n.d. 	- 501 230 -73 **- 351 036** **-90** - 171 180 -88	-84 624 -92 **n.d.** n.d. 	-26 007 -78 **-15 028** **-90** -10 979 - 88

Re1086

Tab. 5: Natural background concentrations (CBG) and average inputs (CBG) of nitrogen (N) and phosphorus (P) in surface waters of Germany (Ø 1993/ 1997) as well as corresponding 2 fold critical levels and loads respectively of running waters (H. Behrendt et al. 2003) compared with recommended critical N and P levels (German EPA / LAWA 2006)

	N	P
1. Background values (Behrendt et al. 2003)		
1.1 Concentrations ($mg \cdot l^{-1}$)	CBG_N = 0.71 (0.44 – 1.05)	CBG_P = 0.034 (0.022 – 0.065)
1.2 Inputs (average) ($t \cdot yr^{-1}$)	IBG_N = 93 370	IBG_P = 3 578
2. Corresponding 2 fold BG values as:		
2.1 Critical levels ($mg \cdot l^{-1}$)	2 x CBG_N = 1.42 (0.88-2.10)	2 x CBG_P = 0.068 (0.044-0.130)
Compare(EPA/LAWA 2006 / I – II)	1.50	0.080
2.2 Critical loads ($t \cdot yr^{-1}$)	2x IBG_N = 186 740	2 x IBG_P = 7 156

Re1085



Fachbereich Pflanzenbau

Input > Output **Input = Output** **Optimum**

no P input :
neither as mineral P nor as organic P

Fig. 1 :The main potential for P loss mitigation <u>and preserve mineral P resources</u> is to maintain soils at or near the lowest mean soil test P (STP) level compatible with good plant production (on soils subject to P loss in overland flow) and match inputs with outputs by yields
[Compare Tunney, Foy et al. IPW5 (2007) : Recommendation for grassland] re1087

Tab. 6: Definition of (optimal) P status for „plant available“ DL and CAL-Phosphorus in agricultural soils and P recommendations

A) new (Köster und Nieder 2004, Isermann 1997/ 2006)

B) at present (VDLUFA-P-Standpunkt 1997)

A) new: 3- classes system (u.a. Köster und Nieder 2004, Isermann 1997/ 2006)					**B) at present: 5-classes system (VDLUFA-P-Standpoint 1997)**				
Classes of P contents	**Reference values [mg P/100g soil] ➔potential eutrophication surface waters**	**Fertilisation needs Input (I) ------------- Output (O)**	**Fertilisation effects**		**Classes of P contents**	**Reference values [mg P/100g soil] ➔potential eutrophication surface waters**	**Fertilisation needs Input (I) ------------- Output (O)**	**Fertilisation effects**	
			Yield increase	**Δ P-content of soils**				**Yield increase**	**Δ P-content of soils**
A (too low)	< 3,0 (< 2,0) ➔ low	I= 2,0 x A	high	Increasing	**A (very low)**	< 2,0	I = 2,0 x O	high	Increasing obviously
					B (low)	2,1– 4,4	I = 1,5 x O	middle	increasing
B (aimed) [1)]	**3,0 – 5,0 ➔ middle**	**I = O**	**low**	**constant**	**C (aimed)**	**4,5 – 9,0**	**I = O**	**low**	**constant**
C (too high)	> 5,0 (> 6,0) ➔ high + depletion of fossil mineral P resources + eutrophication	I = 0 x O	none	decreasing	**D (high)**	9,1 – 15,0	I = 0,5 x O	only with leaf plant	Decreasing slowly
					E (very high)	> 15,1	I = 0 x O	none	decreasing

[1)] **The main potential for P loss mitigation <u>and preserve mineral P resources</u> is to maintain soils at or near the lowest mean soil test P (STP) level compatible with good plant production (on soils subject to P loss in overland flow) and match inputs with outputs by yields**
[Compare Tunney, Foy et al. IPW5 (2007) : Recommendation for grassland] re0936

Tab. 7: The Nitrate Directive of the EU (1991) and its implementation by the German Fertilising Directive (2007) after 16 years: An anachronism of the 21th century as legal options/measures maintaining or even increasing reactive C-, N-, P-, S-emissions from agriculture and therefore eutrophication, acidification, climate change, decline of biosphere and plundering mineral P resources (compare Csathó , Devon 2007)

1. **Only incomplete total field balances, no farm gate balances, no individual field/ plot balances, therefore:**
   1.1 Compension of (too) high with (too) small N and P plot surpluses
   1.2 Neglecting "small" inputs of 50 and 30 kg/ha ·yr of N and P_2O_5 resp.
   1.3 Neglecting N inputs i.e. by atmospheric deposition, late N for cereals and to straw

2. **Tolerated P surpluses of 20 kg P_2O_5/ha · yr of P hypertrophied soils (38%)**

3. **Ca. 50% too high maximum of tolerated (reactive) gaseous N emissions of 45% (grazed grassland 75% !) from animal excretions**

4. **No best available techniques (BAT) for reducing gaseous N emissions are required**

5. **4-5fold too high "tolerable" maximum farm gate N surpluses of 175-245 kg N/ha· yr for arable crops / grassland between 2008 and > 2011**

6. **2fold too high "tolerable" N surpluses of max. 160 kg N/ha · yr for vegetable crops**

7. **Promoting industrial (3,3-4,3 AU/ha instead of agricultural animal production (< 1.0 AU/ha) with P surpluses of 61-79 kg P_2O_5 ha · yr, also by EU subsidies => ca. 8% increase of animal stockings till 2010, ca. 140% more animals than needed for a healthy human nutrition with animal food**

8. **Too short prohibition times for N and P fertilization of only 3.0 (arable land) and 2.5 (grassland) months during winter times instead of 6.0 months**

9. **No humus/C-balances => EC No 1782/2003 (Cross compliance / modulation)**

10. **No penalties if there are offences against Düngeverordnung**

re0937

Tab.8: Driving and preventing forces in the development / implementation of a sustainable nutrition system i.e. in Germany

<table>
<tr><th rowspan="2">Sectors of Sustainability
➔ Aims</th><th colspan="2">Development / Implementation of a sustainable nutrition system</th></tr>
<tr><th colspan="2">Preventing forces
(Inter-)National Lobbies ➔ Lobbyism ➔ Corruption</th></tr>
<tr><td>Social conditions
➔ Sufficiency
[needed food]</td><td>1. Instead pf Net economic growth Cross economic growth (Cross national product /GNP) vs. Sufficiency
2. Apparent efficiency vs. sufficiency (Best) Available Techniques vs. Sufficiency
3. Ignorance of overnutrition</td><td rowspan="3">1. Widespread (inter-)national lobbyism, esp. in respect to legislation, jurisdiction and execution referring to production, trade, consumption, esp. of animal food and environmental problems, mainly by:
▫ Farmers organisations
▫ Organisations of: Fertilizer-, Feed-, Food-, Industries and Trade
▫ Waste and Waste Water Authorities together with
▫ Governmental institutions like ministries
2. No ratification of the UN conventions against corruption in Germany:
Corruption of governmental members are tolerated and not punished
Main sectors and institutions involved in corruption in Germany (Rank 16):
▫ Political parties
▫ Parliament
▫ Business
▫ Justice
▫ Police
▫ Tax offices
▫ Information systems (anti-Transparency)
▫ Public Health System
▫ (Military)
▫ Education System [Transparency International (2006), Friedrich-Ebert-Foundation, 2006)]</td></tr>
<tr><td>Environment
➔ Consistency

[of natural-near ecosystems and natural nutrient resources (esp. N and P)]</td><td>Ignorance of:
1. environmental problems i.e. global climate change
2. Exhaustion of natural/nutrient resources i.e. of N (fossil energy) and mineral P</td></tr>
<tr><td>Economy
➔ Efficiency

[optimization output / input = food / nutrients]</td><td>1. Price dumping i.e. of agricultural products/food, esp. EU/WTO ➔ Globalisation
2. Low Taxation and Subsidy policy (agriculture and food)
3. Unfair trade
4. Illegal (shadow) economy: i.e. Germany most important economic sector with 15% of GNP (2006) ➔ increasing tendency ➔ Index of Sustainable Economic Welfare (Cobb and Cobb 1990)
5. (Inter-)national financial collapse</td></tr>
</table>

Tab. 9: Nitrogen balance (farm level) of agriculture in Germany:

A) Present non-sustainable (Ø 2001 – 2003): Unhealthy human nutrition, N emissions 2-5 fold too high

B) Future sustainable (2020): Healthy human nutrition, emissions equivalent to critical N levels and loads of all natural near ecosystems according to the National Strategy for Sustainability of Germany (2008)

Inhabitants [10^6] = cap	**82.5**		**< 82.5**
Agricultural area (aa) [10^6 ha]	**17**		
Animal stocks [10^6 AU] (EUROSTAT) **Animal densities [AU · ha aa^{-1}/· cap^{-1}/LW· cap^{-1}**	**19** **1.12/ 0.23 / 1.92 AU [100]**		**8.25** **0.49 / 0.10 / 0.83 [44]**
Authors	**Bach and Frede (2007)**	**Isermann (2008)**	
N-Balances	**N-Farm gate balances [kg N· ha^{-1} · yr^{-1}]**		
	A) Present non sustainable (Ø 2001 – 2003)		**B)Future sustainable (2020)**
1. Input / Deliveries	**166**	**219 [100]**	**85 [39]**
…of them:			
1.1 Mineral fertilizer	106	106	40
1.2 Imported feed	22	22	0
1.3 Domestic feed	12	-	-
1.4 Biological N-fixation	14	(14 + 4=) 18	(26+4=) 30
1.5 Atmospheric Deposition	(net) 9	(20 + 10=) 30	(7+3=) 10
1.6 Sewage sludge + biocomposts	3	(3 + < 1 =) 3	(4+ 1=) 5
1.7 Net-Mineralisation (broken grasslands + fens)	n.d.	(LBEG 2007) (29 + 11 =) > 40	0
2. Output / Enrichments	**166**	**219**	**85**
…of them:			
2.1 Sold products	**60**	**[100] 60**	**[58] 35**
2.1.1 Plant production	39	[100] 39	[66] 26
2.1.2 Animal production	21	[100] 21	I [45] 9
2.2 Surplus (1. -2.1)	**106**	**[100] 159**	**[39] 50**
…off it:			
2.2.1 Soil: Net Immobilisation	**0**	**0**	**0**
2.2.2 Emissions	**106**	**[100] 159**	**[39] 50**
…of them into:			
2.2.2.1 Atmosphere	**n.d.**	**83**	**28**
a) NH_3-Volatisation	31	31	10
b) (De-)Nitrification (N2+N_2O+NO)	(n.d. + 5 + 2) n.d.	(38 +12 + 2=) 52 1)	(15+2+1=) 18
2.2.2.2 Hydrosphere (Behrendt et al. 2003)	**n.d.**	**(68+8=)76**	**(20+2=) 22**
a) Leaching	n.d.	68	20
… of it to groundwater	n.d.	17 2)	5 2)
b) Erosion, surface runoff drainage	n.d.	8	2
c) …of them to surface water	25	25	(LAWA I / II= 2xBG) 7
Nitrogen efficiency (%)	**36**	**27 [100]**	**41 [128]**

1) Rooting zone: < 10 - > 150 kg N· ha^{-1} · yr^{-1} (LBEG 2007); **2) Retention (Denitrification, Nitrate-Ammonification): 75% (Behrendt et al. 2003)** re1049

Table 10: Optimum soil organic matter conditions (SOM or C_{org} = humus) of groundwater-remote sandy and loamy soils under common arable farming and average climatic conditions in Europe derived from 26 long-term field trials in Western Europe (Average yearly temperatures: 6-10°C, average yearly precipitation: 400 –800 mm)
(Körschens 1995/1997, Schulz 1997, Körschens and Schulz 1999, Isermann and Isermann 1999, 2003a-b, Isermann und Körschens 2001, Isermann 2002, 2003, Benbi et al. 2003; completed)

Individual parameters	*Respective optimum conditions of SOM*
1. Contents / Quantities	
1.1 Total SOM	Total SOC= C_{org}: 0.7 % (sandy soil) up to 2.5% (black soil) dependent on the clay content (0.7-21%) Total SON= N_{org}: 0.07% (sandy soil) up to 0.25% (black soil) dependent on the clay content (0.7-21%)
1.2 Decomposable $SOM_{dec.}$ Hot water soluble SOM_{hws} (SOM thickness: 30 cm)	Decomposable SOC= C_{dec}: 0.4 (0.2-0.6)% = 16 (8-24) t·ha^{-1} => C_{hwl}: 25-30 mg·100 g soil matter^{-1} Decomposable SON= N_{dec}: 0.04 (0.02-0.06) % =1.6 (0.8-2.4) t·ha^{-1}
1.3 Mineralised SOM $_{min}$ (e.g. Central Germany: 4% of SOM_{dec})	Mineralised SOC= C_{min}: 640 (320-960) kg · ha^{-1}·a^{-1} Mineralised SON= N_{min}: 64 (32-96) kg· ha^{-1}·a^{-1}
2. Thickness (tillage depth)	<35 (e.g.: black soil) up to > 20 cm (e.g. sandy soil)
3. Qualities:	
3.1 SOC/SON= C_{org}/N_{org}	10/1 (> 8/1 up to < 12/1)
3.2 SOC/SOS= C_{org} / S_{org}	100/1 (> 70/1 up to < 140/1)
3.3 SOC/SOP= C_{org} / P_{org}	150/1 (> 100/1 up to < 200/1)
4. Types	raw humus ➔ moder ➔ mull
5. Maintenance of optimal SOM balance (Mineralisation = Immobilisation)	2 t reproduction-efficient organic susbtance (ROS) · ha^{-1} ·a^{-1} = stable manure / liquid manure of 2 t of dry matter / 10 t of raw mass framyard manure from 1 gross weight unit (GWU) or 1 life weight heavy lifestock unit (LFU) of 500 kg life weight (LW) re0518

Tab. 11 (1 / 5): "Sustainable Land Use for the Nutrition and Biomass (esp. Bioenergy) Systems – A Perspective and Challenge both for Policy and Sciences as fundamental Parts of (inter-)national and global Strategies for Sustainability" (BSNLC 2009)

A) Preparation period: Activities of (inter-)national Policy

A I) International and global Activities:

1. **Agenda 21 of Rio (1992) <= Brundtland-Report 1987:** About 60% of the contents refer to "Sustainable Land Use"

2. **EU-Strategy for Sustainable Development: Commission communications:**
   - **Proposal Gothenburg European Council (COM /2001) 264 final**
   - **Review of the Sustainable Development Strategy – A platform for action (COM /2005) 658 final**

   2.1 Three main aims:

   2.1.1 EU-wide policy framework to deliver sustainable development, i.e. <u>to meet the needs</u> of the present without compromising the ability of future generations <u>to meet their own needs</u> both economically (➔ Consistency), ecologically (➔ Consistency) and socially (➔ Sufficiency)

   2.1.2 From 7 unsustainable trends on which actions needs to be taken, the following 5 trends:

   1. Climate change,
   2. (Bio-)Energy,
   3. Production and consumption,
   4. Natural resources for supply and environment,
   5. Human health

   refer to the:

   2.1.2.1 System Nutrition of Agriculture, Human Nutrition and Health, Waste and Waste Water Management
   2.1.2.2 System production and use of biomass, esp. as bioenergy
   2.1.2.3 Nutrients and corresponding emissions of reactive C, N, P and S

   2.1.3 Member states must draw up national strategies and regularly review progress accomplished

Tab. 12 (2/5): "Sustainable Land Use for the Nutrition and Biomass (esp. Bioenergy) Systems – A Perspective and Challenge both for Policy and Sciences as fundamental Parts of (inter-)national and global strategies for Sustainability" (BSNLC 2009)

A) Preparation period: Activities of (inter-)national Policy

A II) National Activities – One example: "Sustainable Germany: Strategy of the Federal Republic of Germany for a Sustainable Development"

1. **Involved co-operating official agencies:**
   1.1 Council for Sustainable Development (2001-2009)
   1.2 Ministry for Environment and Environmental Protection Agency (EPA)
2. **National Strategy for Sustainability: Perspectives for Germany (2002)**
3. **Progress Report 2008 to the National Strategy for Sustainability (Oct. 2008)**
4. **Sustainable Development in Germany: Report on Sustainability Indicators (Destatis / November 2008)**
   ➔ The following 8 (9) of 21 Indicators refer to "Sustainable Land and Soil Use":

   1. Conserving natural resources;
   2. Climate protection;
   3. Renewable energies
   (4. Soil sealing)
   5. Biodiversity
   6. Land Use:
      6.1 Nitrogen surplus of Agriculture: Aimed 2010: 80 and 2020: 50 kg $N \cdot ha^{-1} \cdot yr^{-1}$
      [Compare: Actual N-Surplus 2001/ 2003: 159 kg $N \cdot ha^{-1} \cdot yr^{-1}$ (BSNLC);
      6.2 Ecological Land Use;
   7. Quality of Atmosphere;
   8. Health and Human Nutrition;
   9. Open markets
5. **Environmental Protection Agency (EPA): "Multi-medium (spherical) and multi-system (~ sectional) strategy for the reduction of N-emissions (September 2008 with Workshop/ November 2008)**
6. **HGF-Initiative TERENO: Future German interdisciplinary research program to evaluate the long-term ecological, social and economical impacts if climate change on soils and soil use within numerous regional scales (e.g. C-and N-balances)**

A III) World Wide Activities:

1. **Agriculture and Sustainable Development: ➔ International Assessment on Agriculture Science and Technology for Development (IAASTD) / Paris – April 2008**
2. **University of Technology, Institute of Sustainable Futures, Sydney (D. Cordell, 2009): Sustainable Future in Phosphorus flows**

Tab. 13 (3/5): "Sustainable Land Use for the Nutrition and Biomass (esp. Bioenergy) Systems – A Perspective and Challenge both for Policy and Sciences as fundamental Parts of (inter-)national and global strategies for Sustainability" (BSNLC 2009)

A) Implementation period: (Inter-)national activities of scientific and official Organisations

B I) International activities

1. **EUROSOIL** [Reading (UK) 2000, Freiburg (Germany 2004] **Vienna 2008: Soil –Society-Environment:**
   European Confederation of Soil Science Societies (ECSSS) as regional organisation within the International Union of Soil Sciences (IUSS):
   About 500 Indicators referring to sustainable land and soil use, especially in respect to the 11 main threats on soils:

1. Soil organic matter (SOM)	**4. Salinisation**	**7. Compactation**	**10. Climate change**
2. Eutrophication	**5. Contamination**	**8. Erosion and sedimentation**	**11. Decline in (soil) biodiversity**
3. Acidification	**6. Soil sealing**	**9. Floods and land slides**	

   ➔ 10 of these 11 main threats (except soil sealing) are caused essentially by the systems of
   a. Nutrition with agriculture (production of feeds and foods), human nutrition (food consumption) and waste and waste water management (disposal)
   b. Biomass and esp. bioenergy production (Agriculture, Forestry) as well as consumption
   ➔ 5 of these 11 main threats (1., 2., 3., 10., 11.) are caused /influenced by the nutrients C, N, P, S

2. **Still ended and actually running 11 EU-COST-ACTIONS (1999-2011) , 5 OECD / EU International IPW-Workshops:**
   Mitigation of P losses from agriculture (< 1998-2007), **Nitro Europe; Carbo EUROPE; International Nitrogen Initiative (INI); with: "Research and development of an integrated sustainable C, N, P, S approach in Europe and in the World respectively**

3. **Future perspectives by integration into the approach "Sustainable soil and land use" (Initiatives BSNLC)**

   3.1 Within the International Union of Soil Sciences (IUSS):

   3.1.1 International Working Group for long-term field experiments (ILTE / IOSDV)
   3.1.2 International Working Group of Soil Fertility (IWGSF) with the WG "Practical solutions for managing optimum C and N content in agricultural soils (Conferences Prague 1998 / 2007)

   3.2 International Working Group Lysimeter [Graz (Austria) 2000 / 2009]: Main aspects: Impacts of (un-)sustainable land use on aquatic ecosystems ➔ Needed widespread integration a.o. of 3.1 (3.1.1 + 3.1.2) and 3.2

Tab. 14 (4/5): "Sustainable Land Use for the Nutrition and Biomass (esp. Bioenergy) Systems – A Perspective and Challenge both for Policy and Sciences as fundamental Parts of (inter-)national and global strategies for Sustainability" (BSNLC 2009)

B) Implementation period: (Inter-)national activities of scientific and official Organisations

B II) National activities, taking Germany as an example:

1. **Ministry for Education and Research (2008): National Research Program "Sustainable Land Use" (100 Million € / Proposal final: 27/02/2009) [http://www.bmbf.de/foerderungen/13 138 php]. References: EU-RP-7**

2. **Association of German Agricultural Analytical and Research Institutes (VDLUFA) (Initiative a.o. BSNLC): "Working Group: "Development of sustainable nutrient balances in rural regions (Abrev.: Sustainable nutrient balances)" with actually 2 Sub-Working Groups:**

   2.1 "Precision / Optimization of humus (C) balances (established)
   2.2 Precision / Optimization of P balances (planned)

3. **German Association for Water Management, Wastewater and Waste (DWA / Hennef ➔ IWA) WG "Fate of C , N-, (S) in hydrosphere / aquatic ecosystems** (drainage zone of terrestrial soils, semi-subhydric soils, groundwater, surface waters: Flowing waters, transition (estuaries) and coastal waters, marine waters [➔ EU-Nitrate Directive-Water Framework Directive (WFD) , - Groundwater Directive (GD),- EU and National Marine Framework Directive (MFSD, MSRL)] ➔ **Sustainable Water Management in respect to C, N, P, S (**Established: June 24, 2009/ Hennef) (Initiatives a.o. BSNLC)

4. **Section Nutrition of Woodlands within the Association of German Forest Research Institutes (DVFFA): "Sustainable Use of Woodlands from the view point of nutrition"** (Main point conference Sept. 18 / 19, 2009 [Initiative TUM]

5. **German Society of Soil Sciences (Conference Bonn / Sept. 5-13, 2009) WG: Sustainable land and soil use esp. from the view point of the 11 main threats of soils and the systems nutrition as well as biomass (esp. bioenergy) production and use** (Planed: Initiative BSNLC)

Tab. 15 (5/5):

A) Main results and conclusions of BSA / BSNLC (1994-2009) referring to “Sustainable Land Use for theNutrition and Biomass (esp. Bioenergy) Systems (About 140 publications)

1. **Indicators (Critical levels and loads) and corresponding needed cause-oriented and sufficient mitigation options integrated simultaneously:**

   1.1 Within and between the 5 environmental spheres (Pedosphere, Lithosphere, Atmosphere, Hydrosphere, Biosphere) mainly in respect to the reactive emissions / immissions of C, N, P, S (➔ *Consistency*)
   1.2 And Anthroposhere: Human Nutrition and Human Health (➔ *Sufficiency*)
   1.3 Economically: Financial implementation (➔ *Efficiency*)

2. **Corresponding approaches /examples**

   2.1 National: Germany (i.e. needed and implementation of a maximum N surplus in German agriculture till 2020 of 50 kg N· ha^{-1} · yr^{-1} (Farm gate balance)
   2.2 International: EU-27, Asia (PR China)

3. **Recent References: About 30 contributions of BNLSC i.e. for:**
   3.1 EU-RP5-daNUbs: Nutrient Management in the Danube Basin and its Impact on th Black Sea: (2001-2005) (non)sustainable Scenarios: Agriculture, Human Nutrition, Waste and Waste Water
   3.2 EU-COST-869 (2006/ 2009-2011): Mitigation options for nutrient (N+P) reduction, in surface waters and groundwater (WG 3: Mitigation options)
   3.3 OECD-International Phosphorus Workshops (IPW3-5): 1998-2007: Mitigation options for P reduction
   3.4 EUROSOIL (2004➔2008): Sustainability indicators for Environment (C, N, P, S) and Human Nutrition/Health and Biomass Systems
   3.5 IWGSF / IUSS (2003-2007): Role of (inter-)national legislation to optimize soil organic matter and human nutrition
   3.6 International Working Group Lysimeter (1995/2000-2007): Role of (inter-)national legislation on the (non-)sustainable nutrition system, esp. agriculture
   3.7 German Society of Soil Sciences (2005-2009): Sustainable land use in respect to the 10 main threats of soils (nutrition biomass)
   3.8 German Environmental Protection Agency (2008): Multi-medium and –system strategy for the reduction of N emissions
   3.9 German Association Agricultural Analytical and Research Institutes (2005-2009): Sustainable Indicators and mitigation options for the nutrition and biomass (esp. bioenergy) systems referring to sustainable nutrient balances (esp. C, N, P, S)
   3.10 German Institutes for Environmental, measurements and protection of nature Baden-Württemberg (2000-2007): Emission factors and emissions for volatile reactive C and N compounds and fine dust from biogenic sources in Baden-Württemberg and Germany