

How to Achieve A Good Nutrient Balance in Our Environment

The Key to a Healthy Planet, Healthy Living!

Brought to you by your good friends from the
Global Nutrient Cycle Project (GNC)
and
**Toward an International Nitrogen
Management System Project (INMS)**

9th GEF International Waters Conference
Marrakesh, Morocco



Meet your **Nutrient Medics**



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IIASA, Austria

Nutrients...a pain in the Environmental Neck?

How can we help?



Nutrients...a challenge?

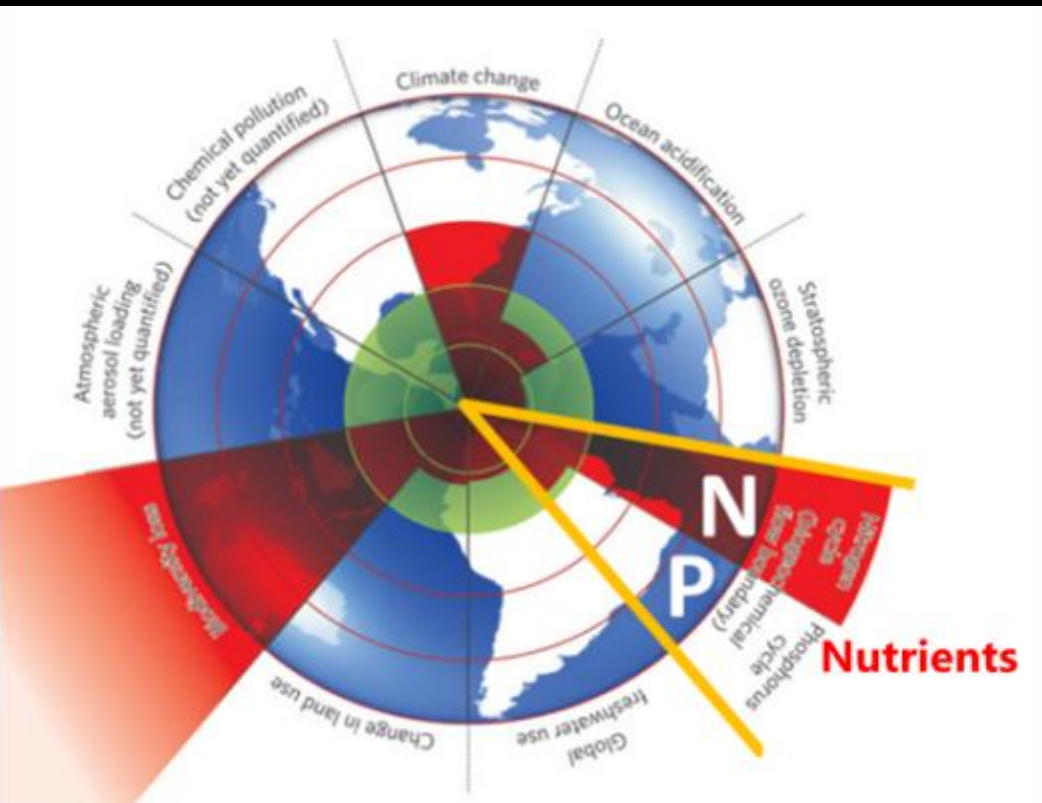


Source: <http://studentbodyuf.com>

Nutrients...a good thing!

But too much or too little...**not so good!**

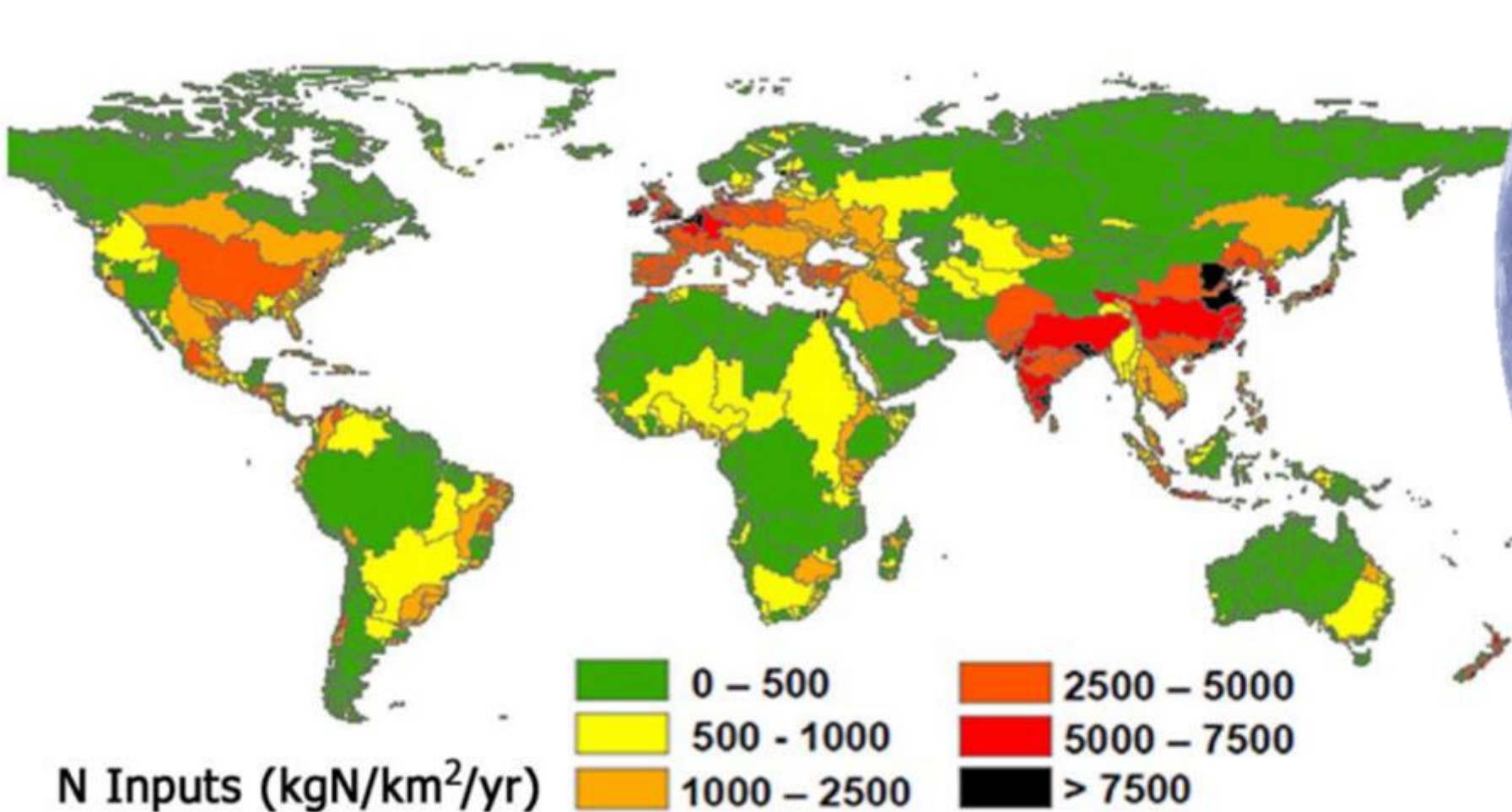
Planetary Boundary for Nitrogen is greatly exceeded;
boundary for Phosphorus is being approached



Planetary boundaries define safe operating space for humanity with respect to the Earth system



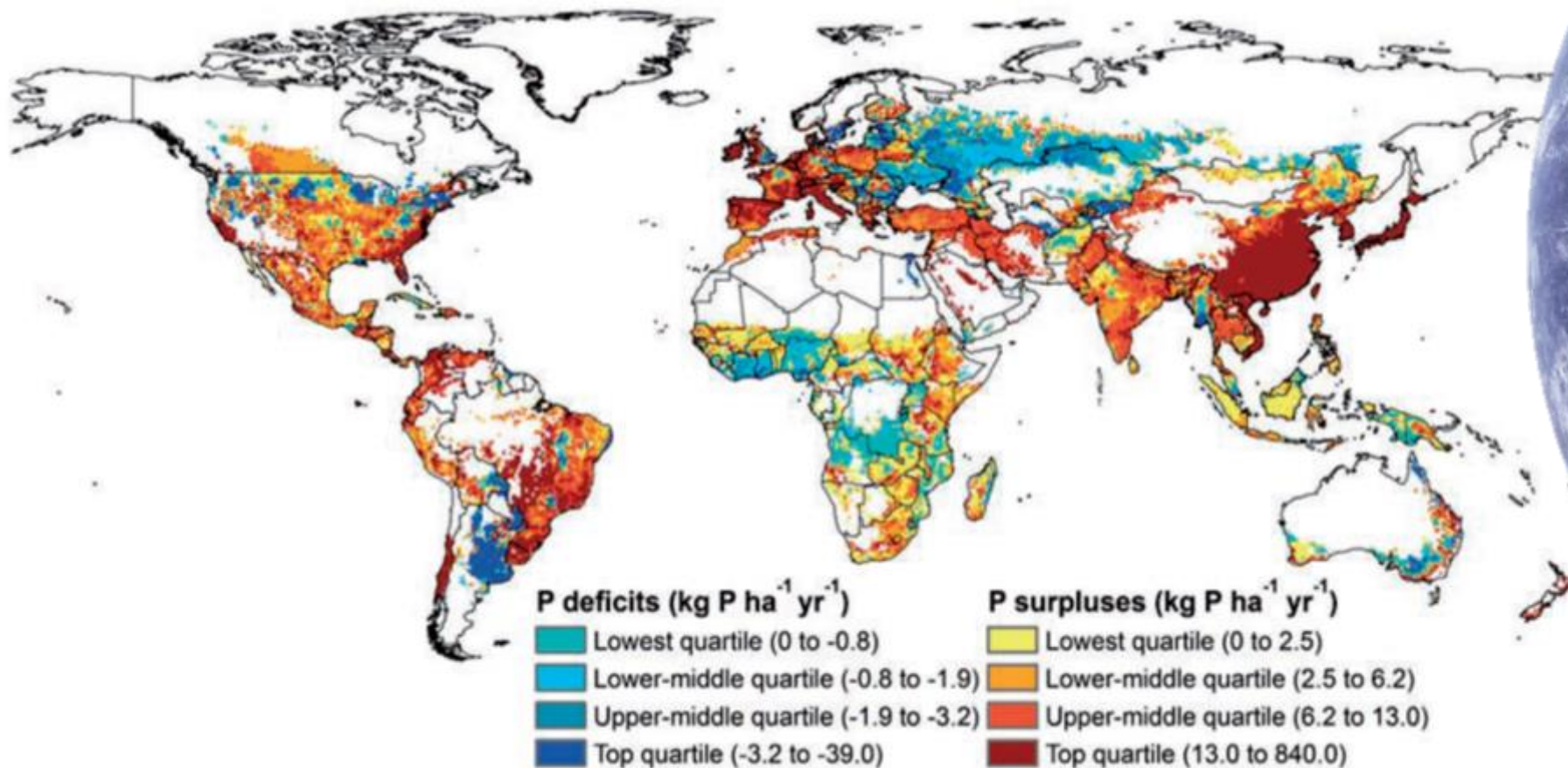
Too Much and Too Little Nutrients: **The case of Nitrogen**



Estimated net anthropogenic nitrogen inputs according to the world's main river catchments (Source: Our Nutrient World 2013).



Too Much and Too Little Nutrients: **The case of Phosphorous**



Estimated global phosphorus surplus and deficit. Source: Our Nutrient World, 2013, citing (MacDonald et al., 2011)

Nutrients....a good thing!

But too much or too little... **not so good!**



Modified from the European Nitrogen Assessment (2011)

- The **WAGES** of too much or too little Nitrogen and Phosphorus
- Multiple impacts across several environmental areas
 - **W**ater quality
 - **A**ir quality
 - **G**reenhouse balance
 - **E**cosystems
 - **S**oil quality



Too much nutrients....

Sources

Untreated wastewater



Fertilizer excess runoff

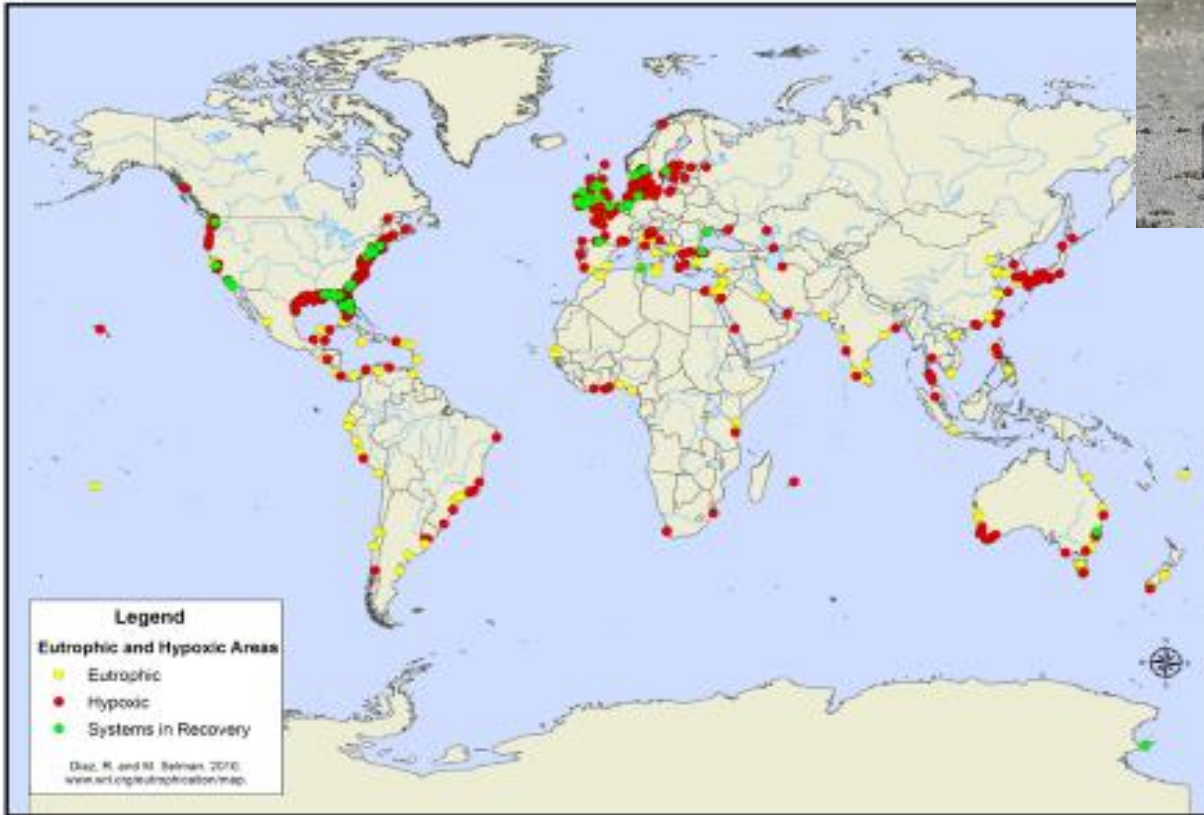


Livestock waste runoff



Air pollution





**3 kids died, 64 taken ill
due to red tide poisoning**

THREE students have died and 44 people are taken ill by one of the following, measles and infectious mononucleosis.

Marigat introduced about 3 years ago, California State of California, University of Texas: Ernesto Ruiz, 16, and American-Italian 17 years old, of Black 18, Lat 29, Brown 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837,



REED (also visited at the PC)

Article from the *Philippine Daily Inquirer* on May 19, 1995, reporting victims who ate green mussels collected from Manila Bay. Used with permission.



Too little nutrients...

Harvest more than is replaced by nutrients - **nutrient mining**, reduced crop yield and failure



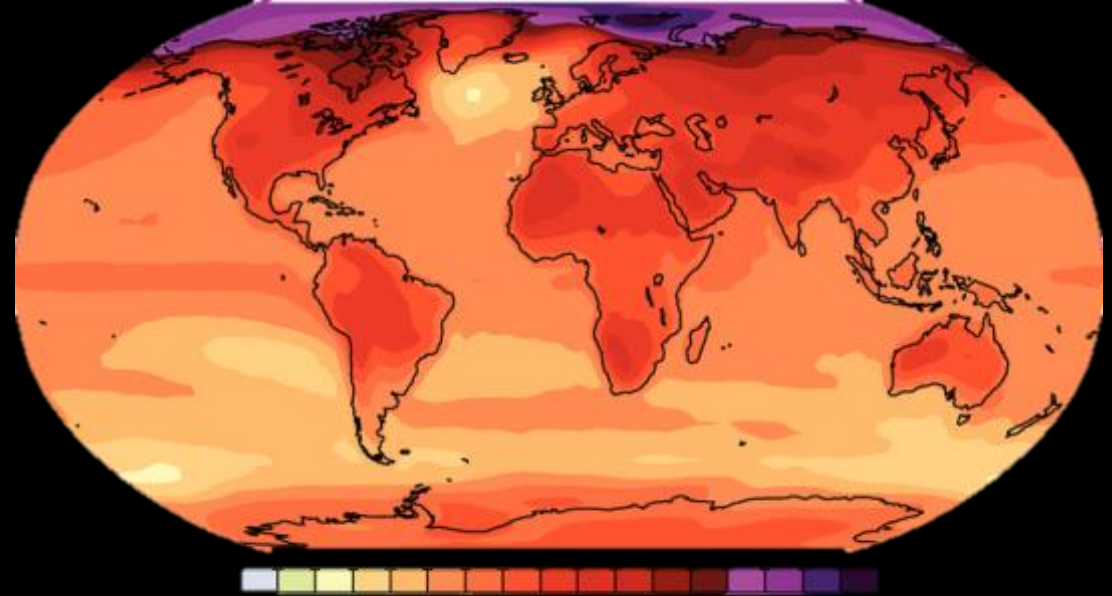
Land degradation



Poor nourishment, social conflict



And on top of all that.... **Climate change**



Bleached corals...further weakened due to nutrient pollution

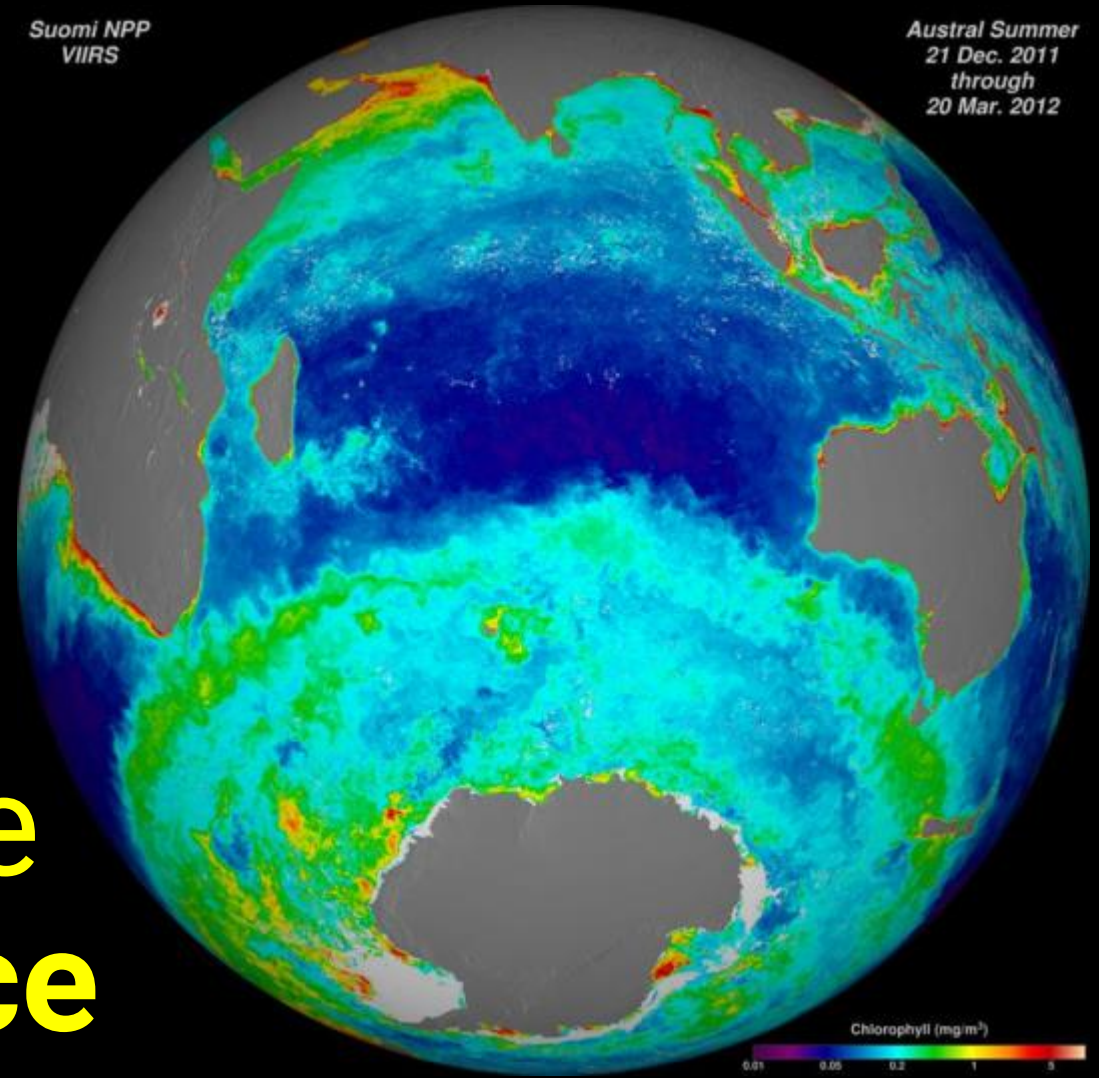


Deoxygenation of marine waters



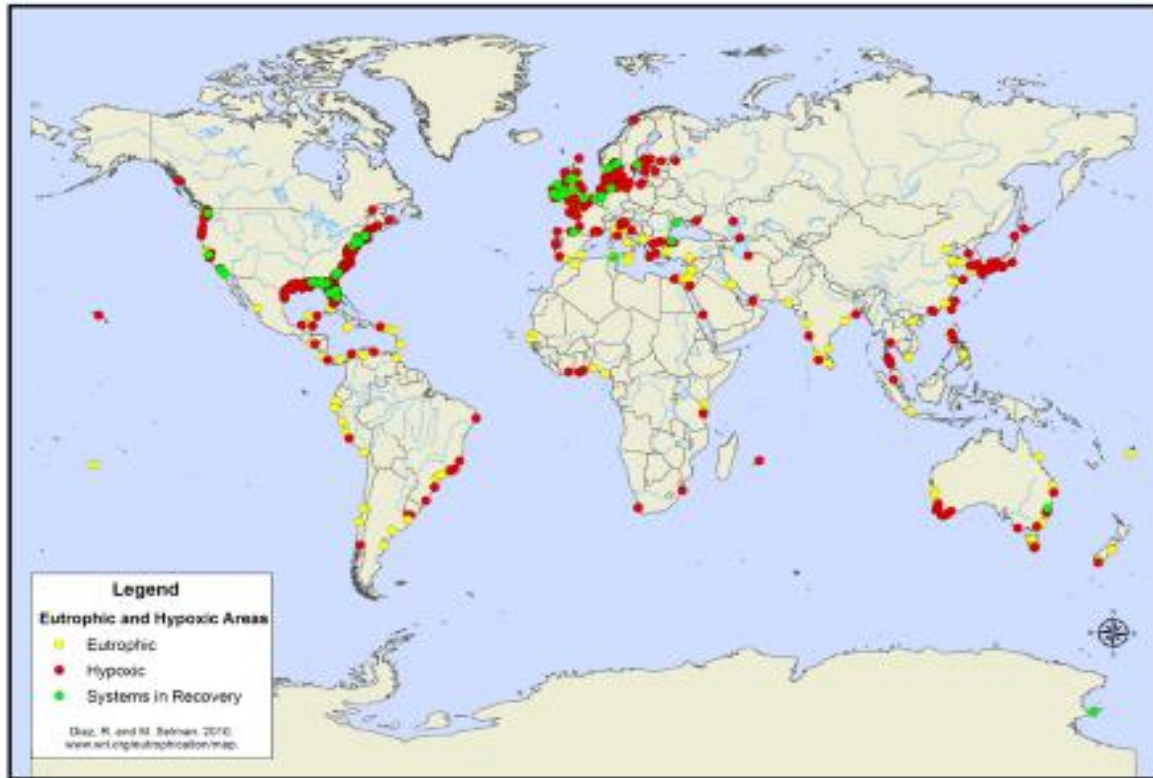
Releases of nitrous oxide

How big is big?
Measuring up the
Nutrient Nuisance



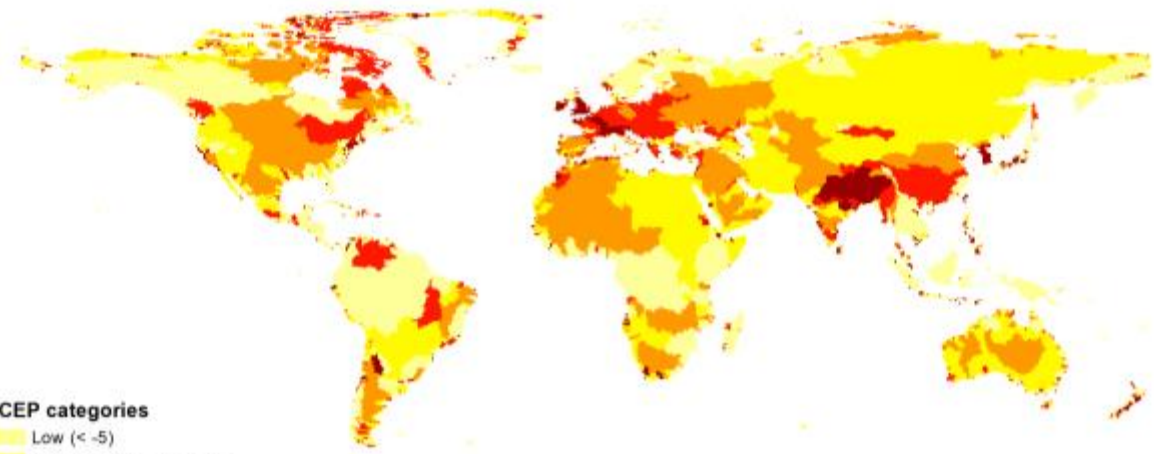
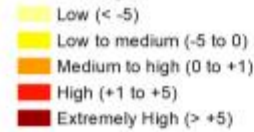
Measuring up the Nutrient Nuisance

World Hypoxic and Eutrophic Coastal Areas

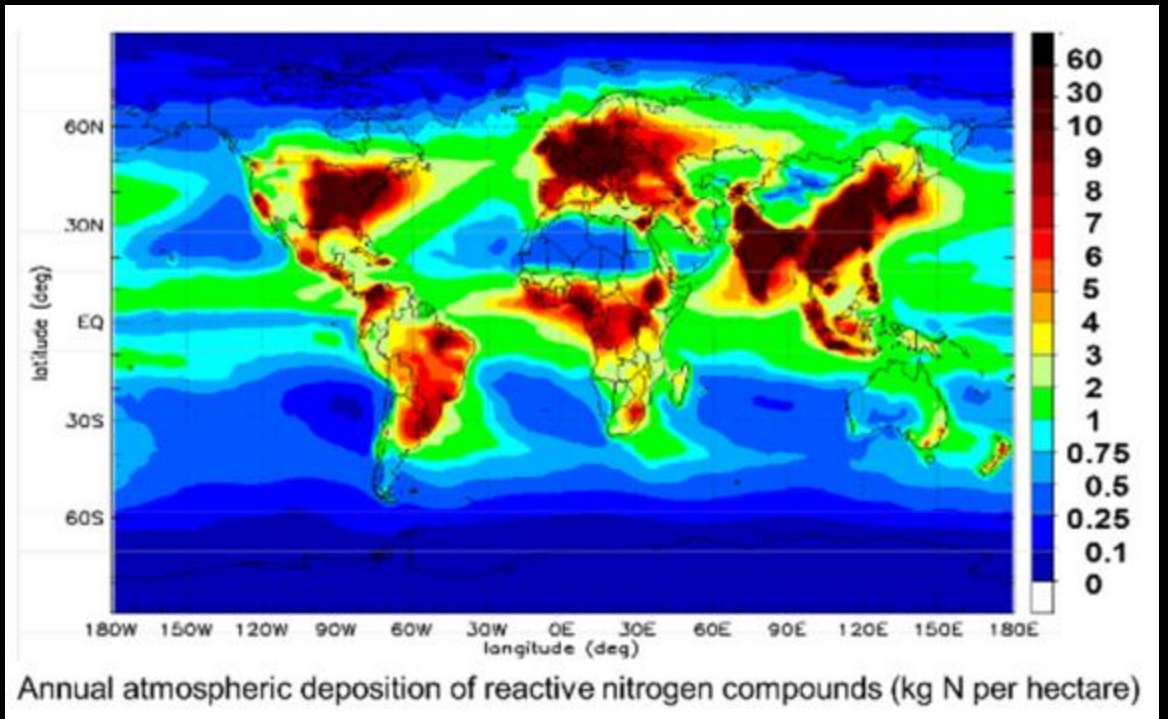


Deadzone occurrence

ICEP categories



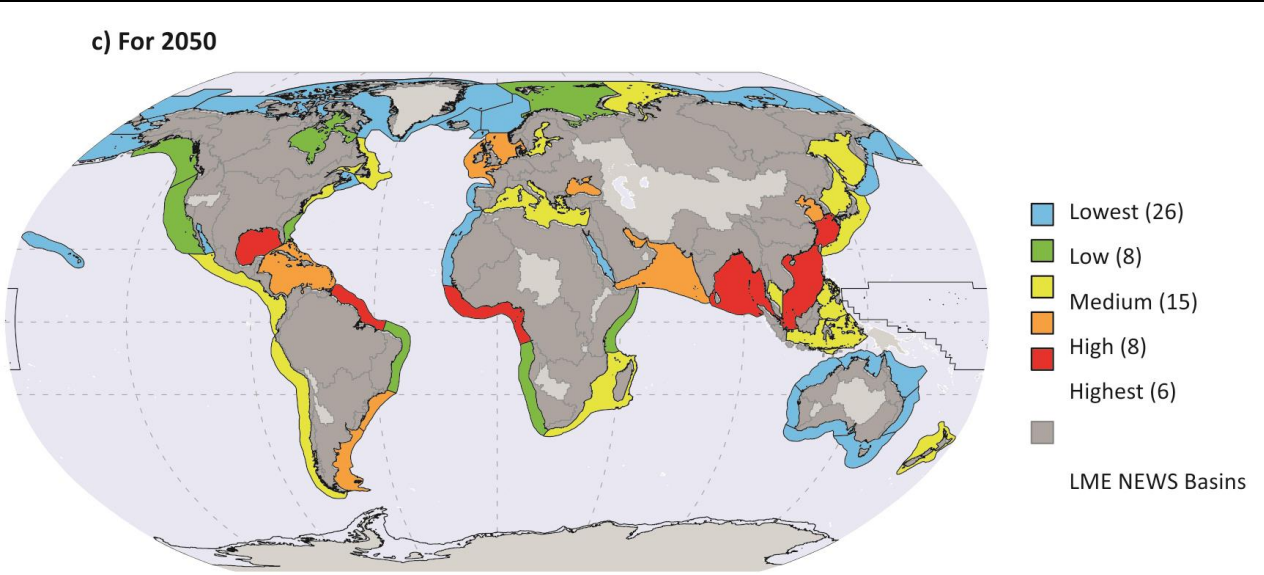
Eutrophication potential



Atmospheric deposition of N

Measuring up the **Nutrient Nuisance**

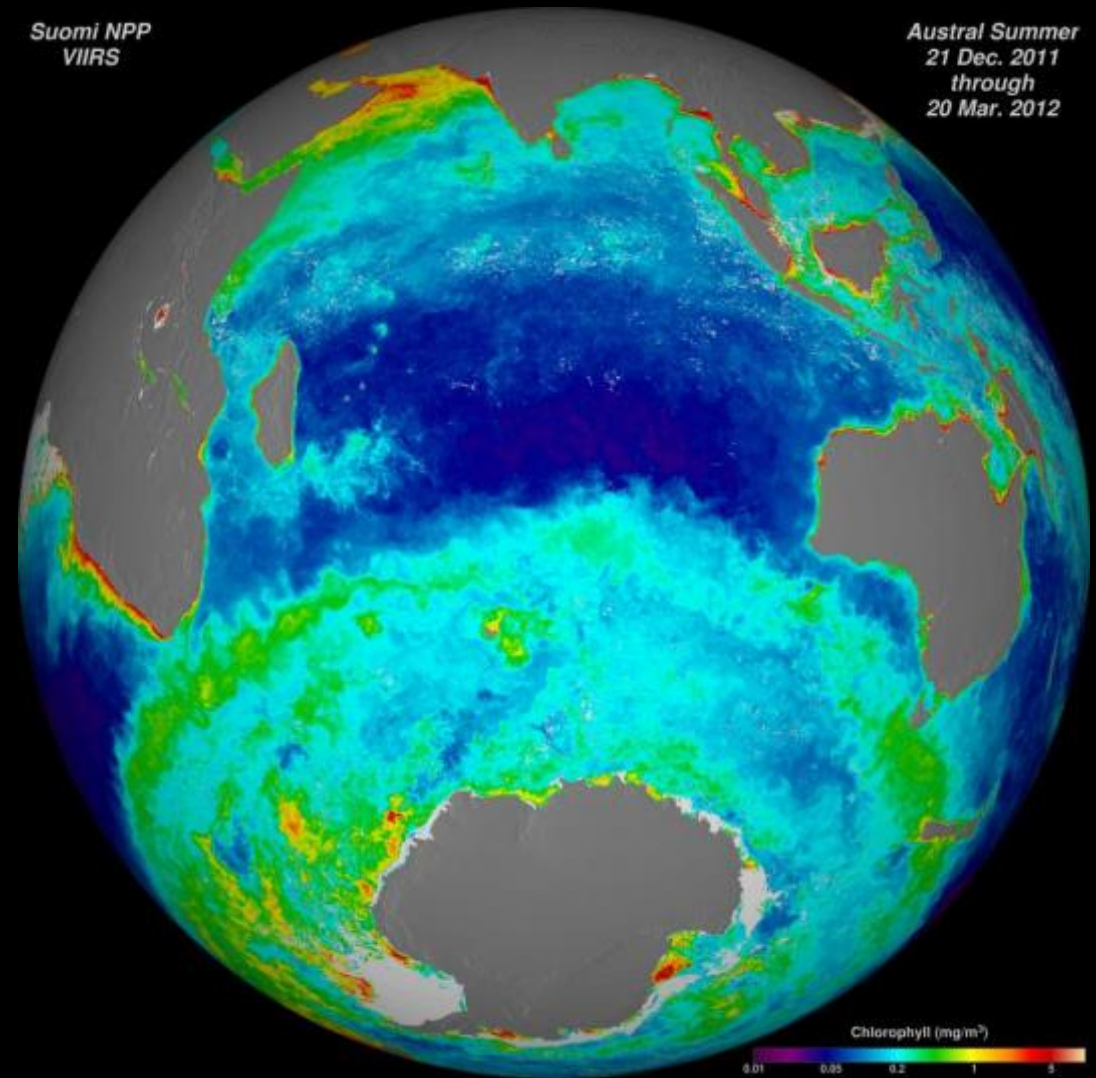
Scenarios: nutrient risk (from GEF-TWAP Project)



Oxygen content in Gulf of Mexico



Ocean Chlorophyll Concentrations
Source: NASA

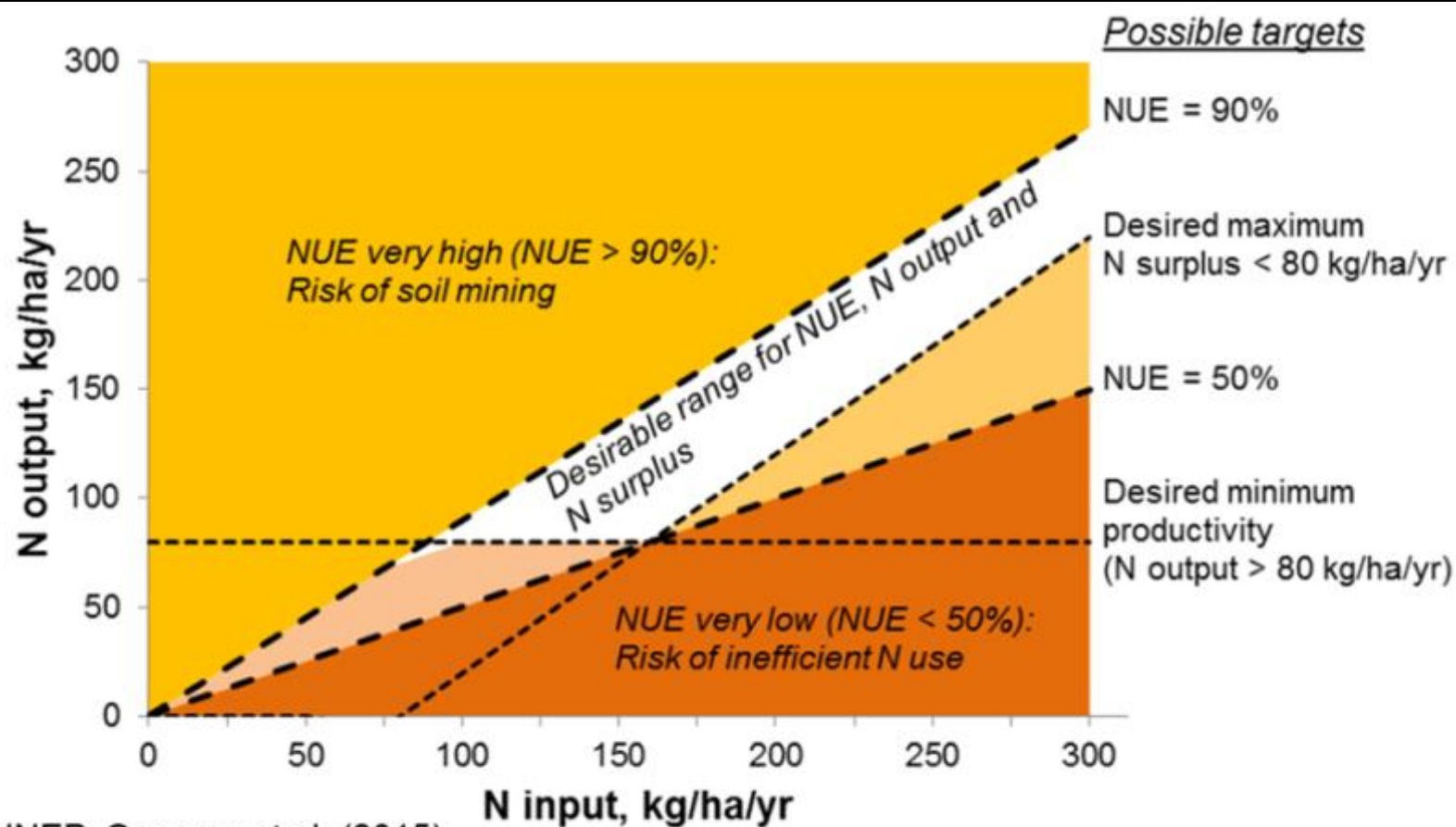


“Nickking Nutrients **NOW!**”
We got the **Tools to Tackle!!**



Tools

Estimate Nitrogen Use Efficiency (NUE)



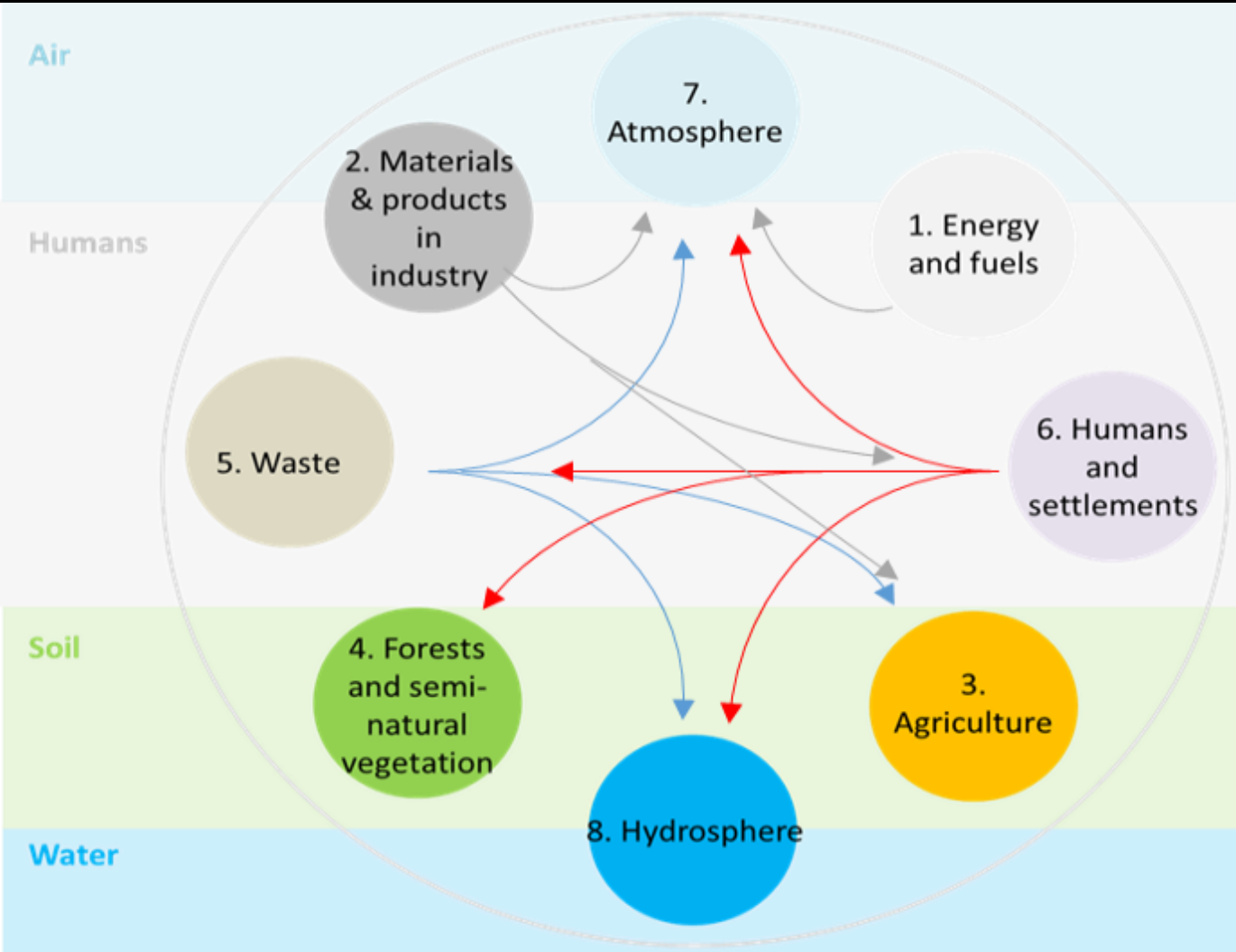
UNEP, Oenema et al. (2015)

For crop systems

- Determine N surplus, N input, N output and input/output ratio (NUE)
- Compare agricultural systems
- Compare countries
- Improve efficiencies to **reduce costs and enhance environmental performance**

Tools

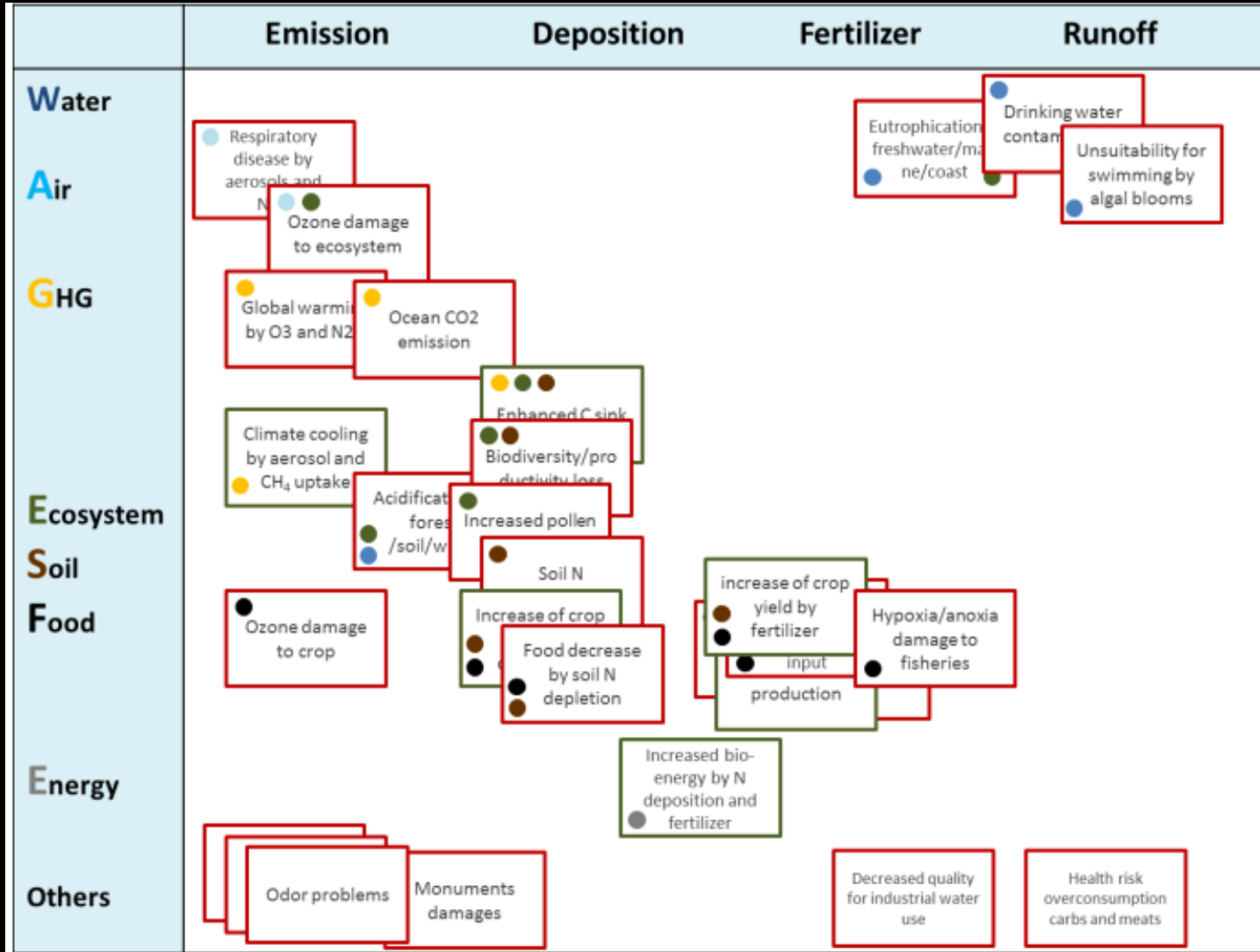
National Nitrogen Budgets



- Divide a country into pools
- Define flows between pools
- Quantify individual flows
- Identify discrepancies, derive “most probable” solutions
- Discover data limitations and improve data quality
- Rank flows and their respective impacts
- Benchmark different countries
- Derive trends

Tools

Threat – benefits mapping

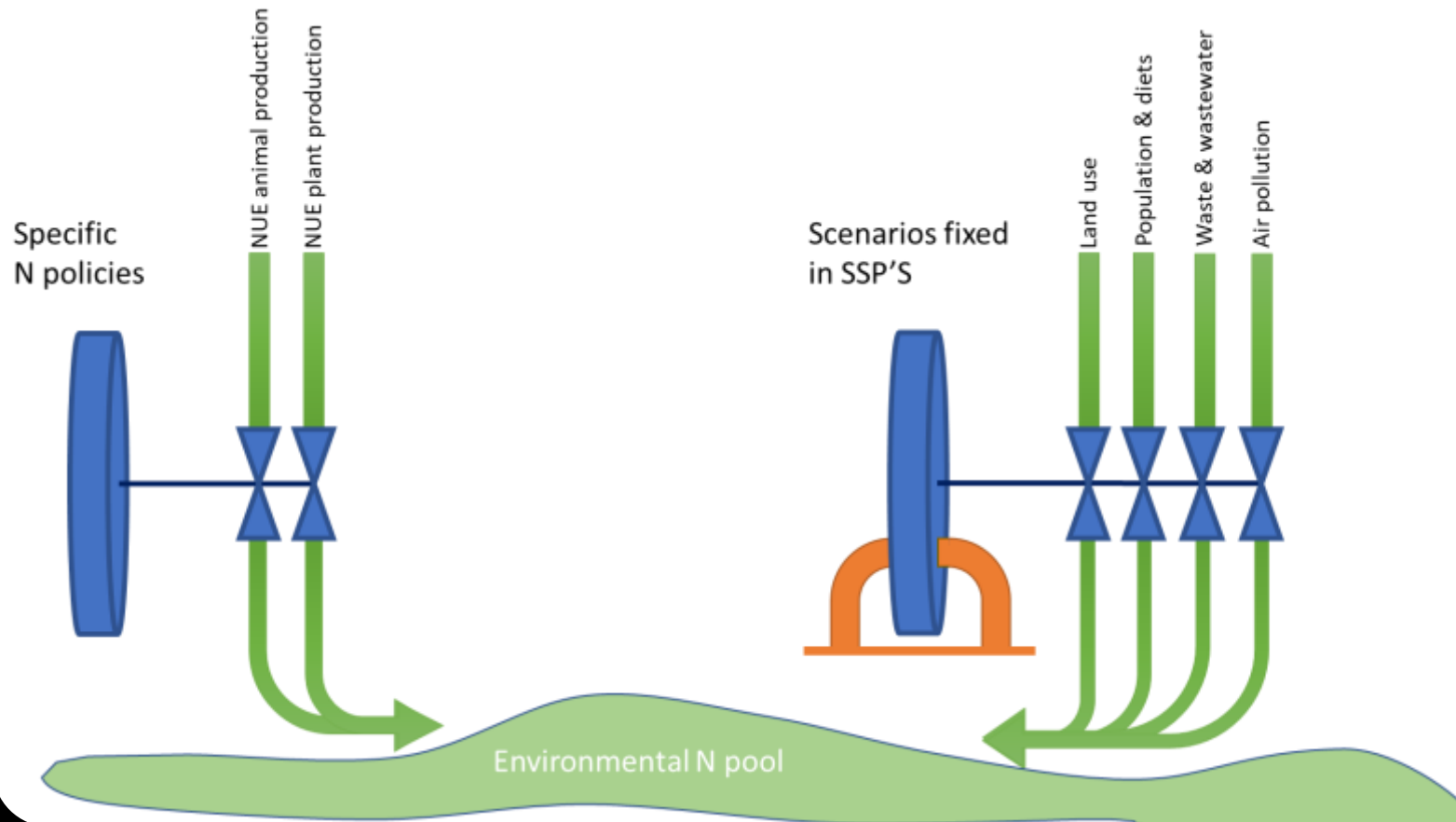


- Identify multiple issues caused by single emission
- Weigh potential benefits against damage
- Cluster different effects by environmental media, by occurrence
- Allow for the allocation of the cause, or the causing agent

Tools

Future nitrogen scenarios

INMS add-on



Climate Scenarios (IPCC):

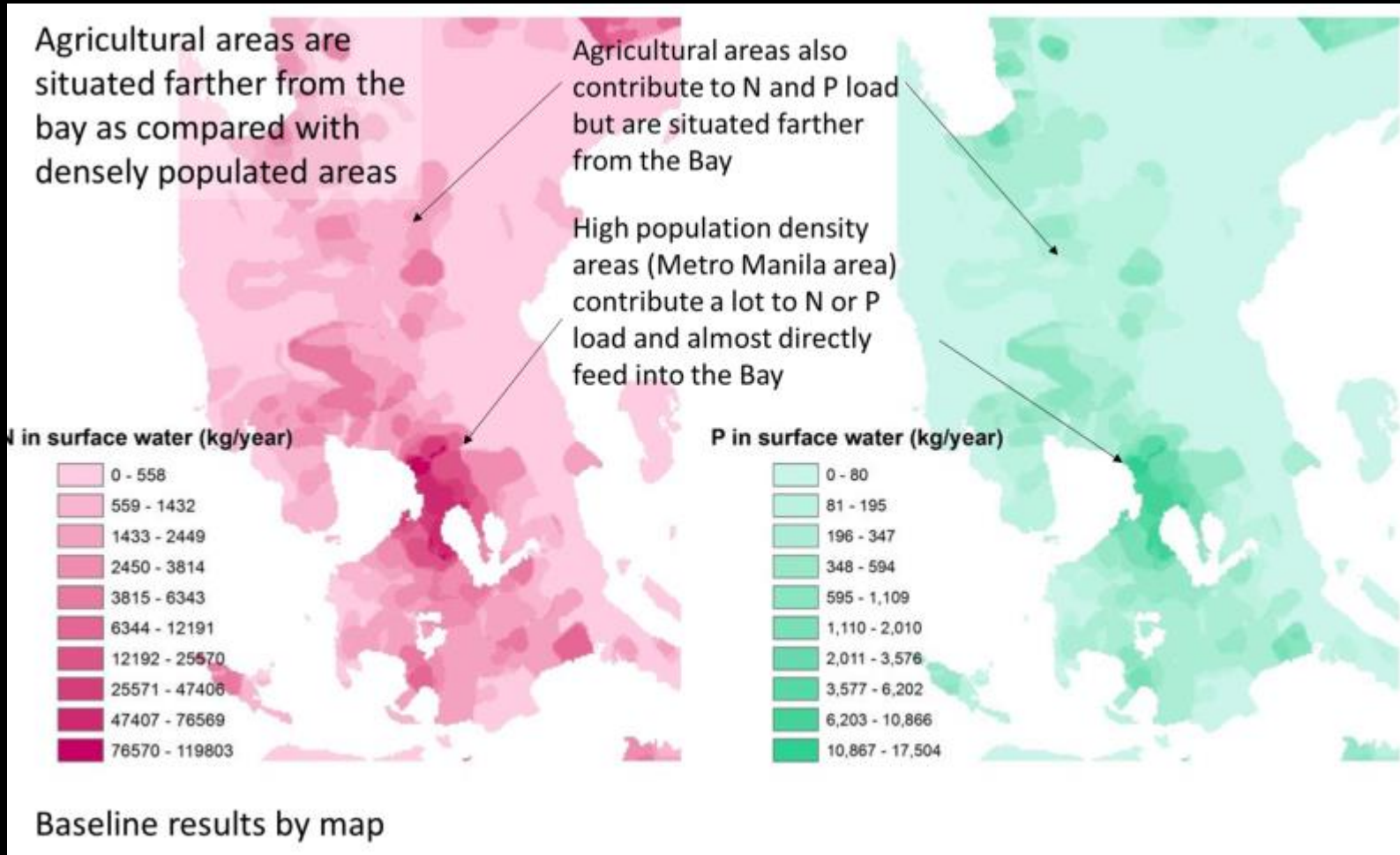
- Socioeconomic Pathways (SSP's)
- GHG concentration paths (RCP's)

Matrix (5 X 4; some infeasible)

- Extends to 2100
- Rich scientific dataset

Tools

Watershed-based **nutrient flux modelling**



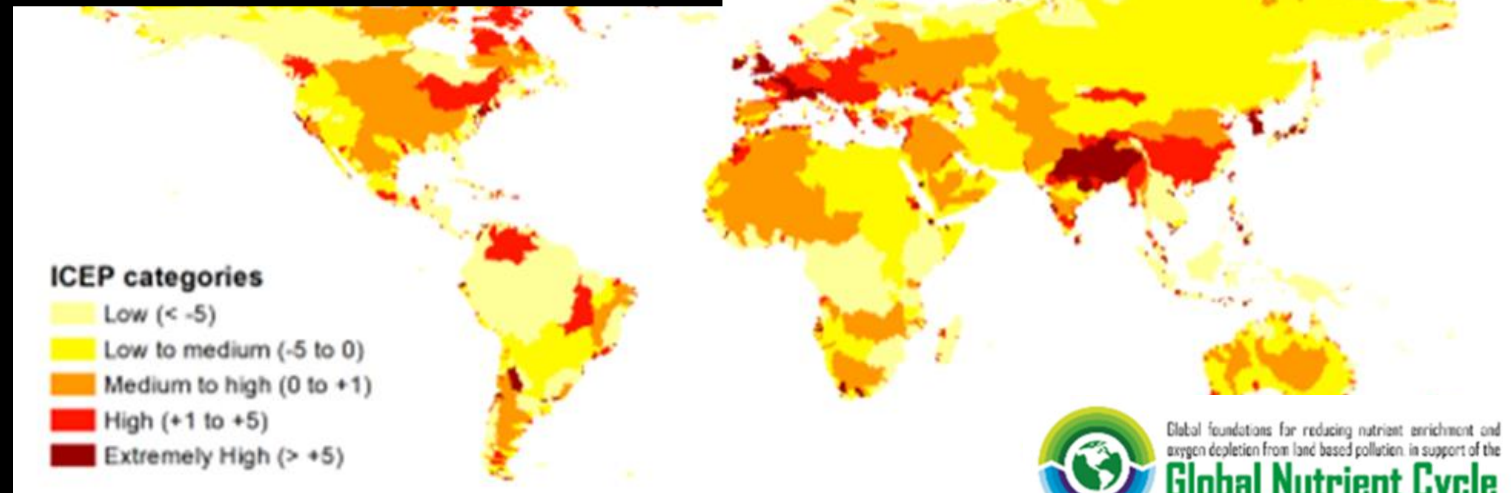
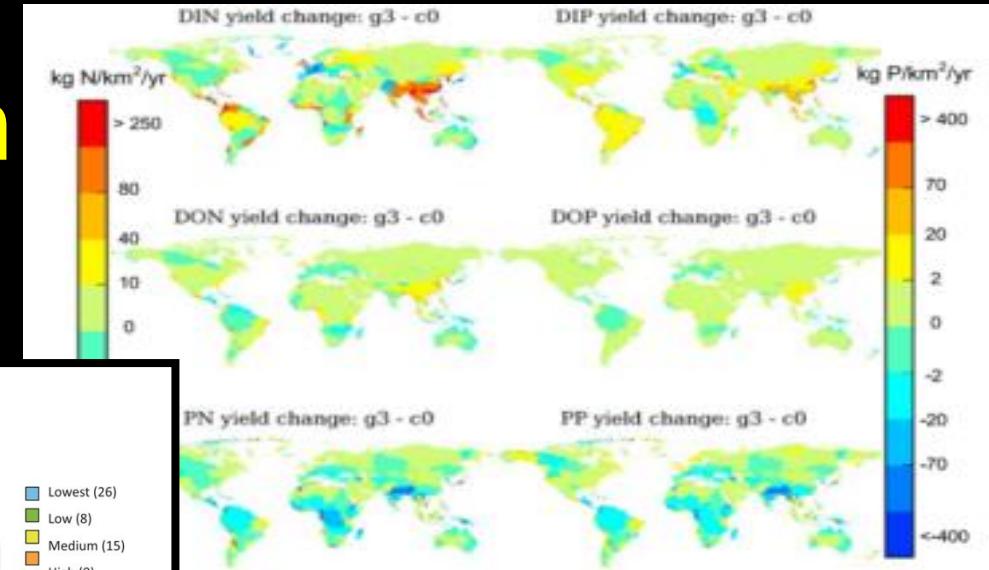
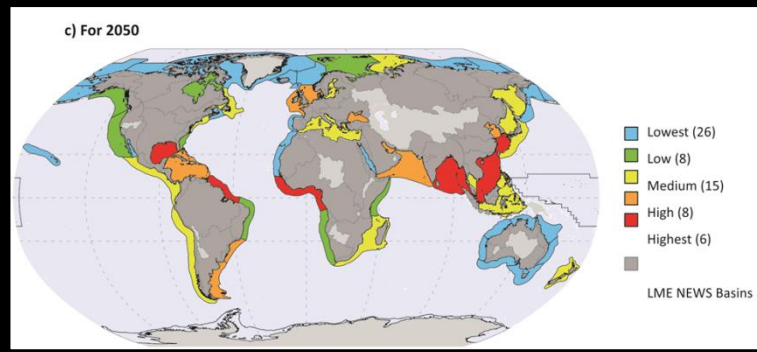
- **Example from Manila Bay, Philippines**
 - Population
 - N and P inputs
 - Sewage connections
 - Sewage treatment level
- Scenario evaluation based on developmental pathways

Tools

Predicting coastal eutrophication

Looking to year 2050

- Based on the **Global NEWS model** - 6,000 river basins
 - Climate/soils
 - Land use/activities
 - Population
- **Index of Coastal Eutrophication Potential (ICEP)**
 - Ratio between delivery of N, P and Si from watershed
- Indicate relative dominance between diatoms and algal species (leads to eutrophic conditions)

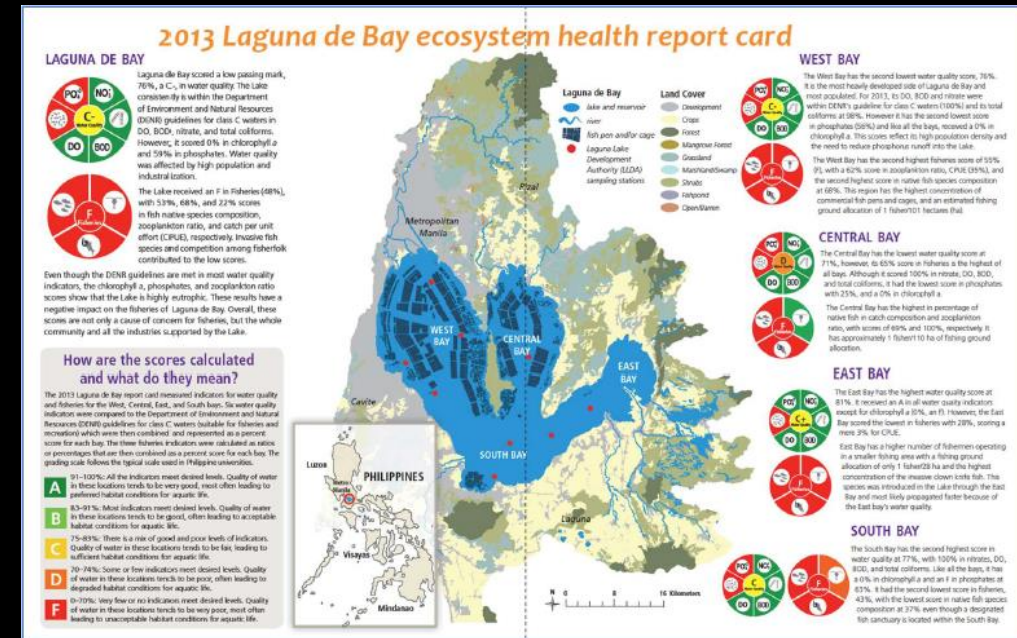
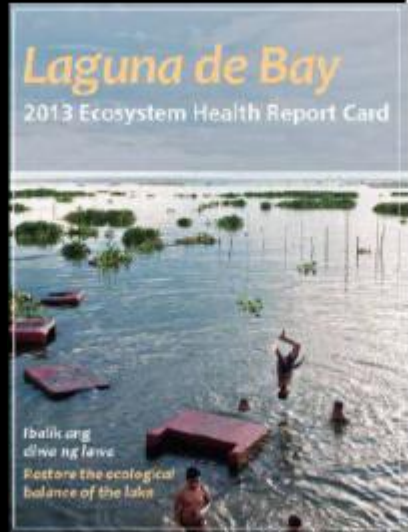
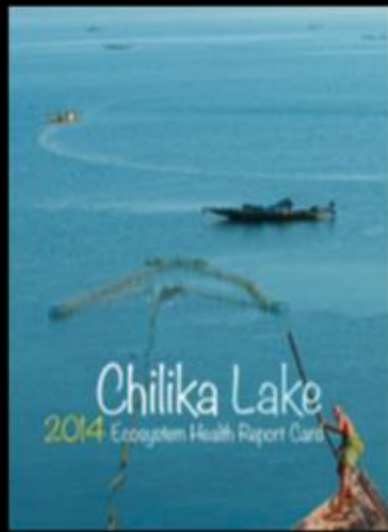


Tools

Ecosystem Health Report Cards

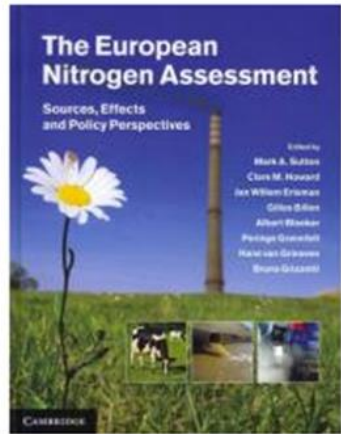


- Parameter selection
- Set limits and assign health scores
- Collect data; analyze and report



Tools

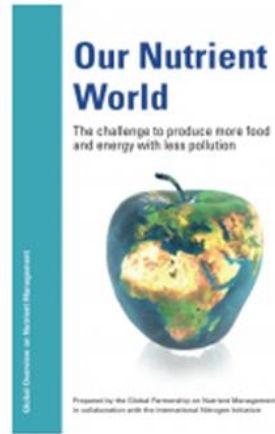
Publishing towards policy impact



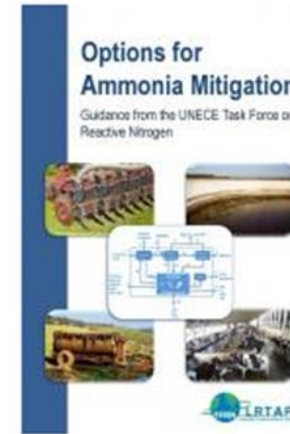
European Nitrogen Assessment...
M.A. Sutton; C.M. Howard; J.W...



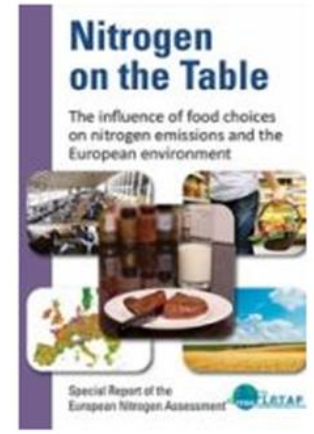
Drawing Down N2O to Protect...
J. Alcamo; S.A. Leonard; A.R...



Our nutrient world: the...
M.A. Sutton; A. Bleeker; C.M...



Options for Ammonia...
S. Bittman; M. Dedina; C.M...

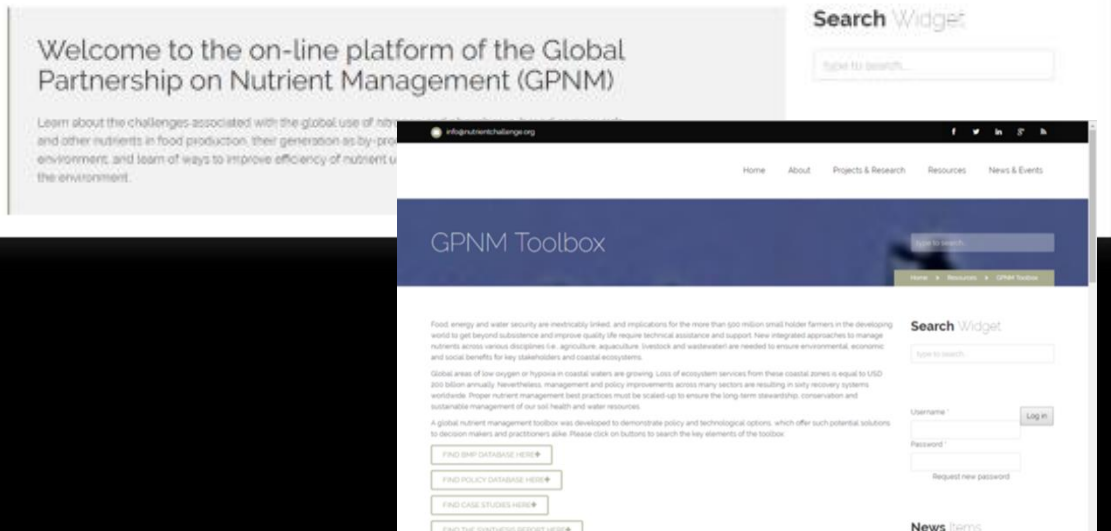
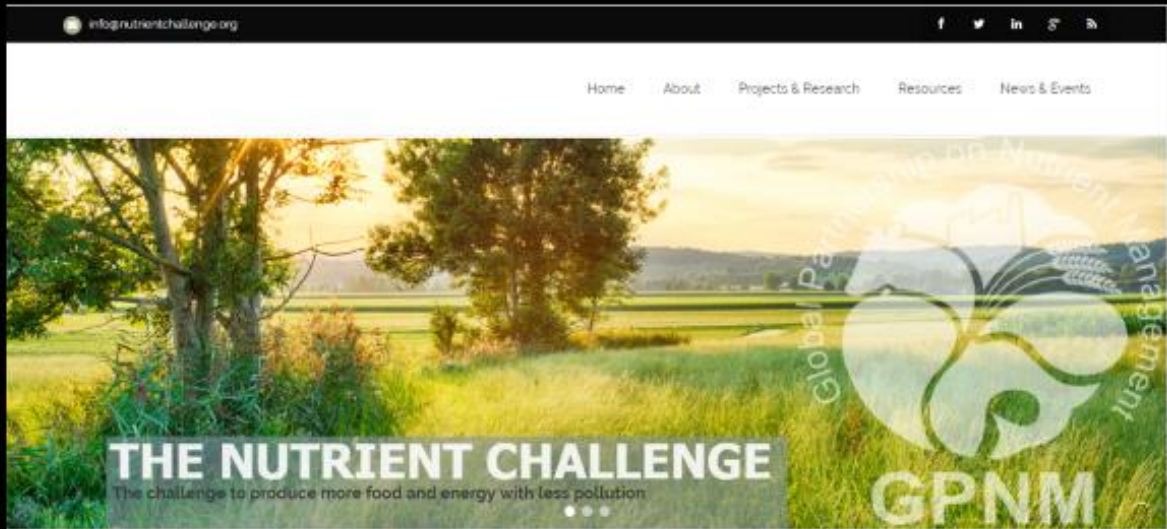


Nitrogen on the Table: The...
H. Westhoek; J.P. Lesschen; A...

- High quality assessment reports to trigger policy interest
- Taking advantage of appropriate platforms

Tools

Global Nutrient Management Toolbox



What will it mean for all of us?
A New Nutrient Narrative



Setting Goals!



**SUSTAINABLE
DEVELOPMENT**

GOALS

Core SDG targets related to sustainable nutrient management:

- Target 2.4 – sustainable food production
- Target 6.3 – good ambient water quality
- Target 14.1 – reduced nutrient pollution in the marine environment



The business of nutrients

...can we sell this?

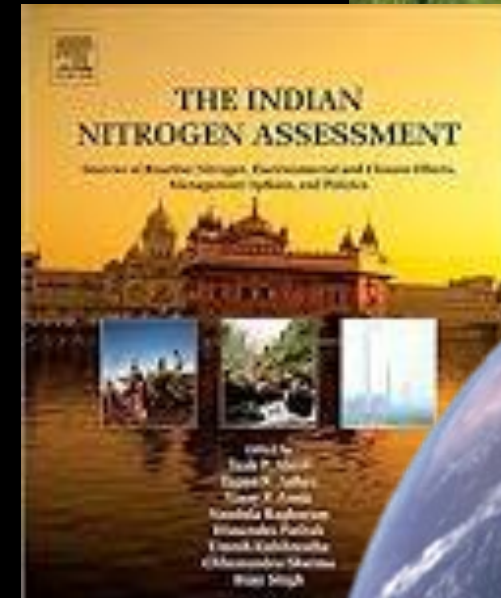
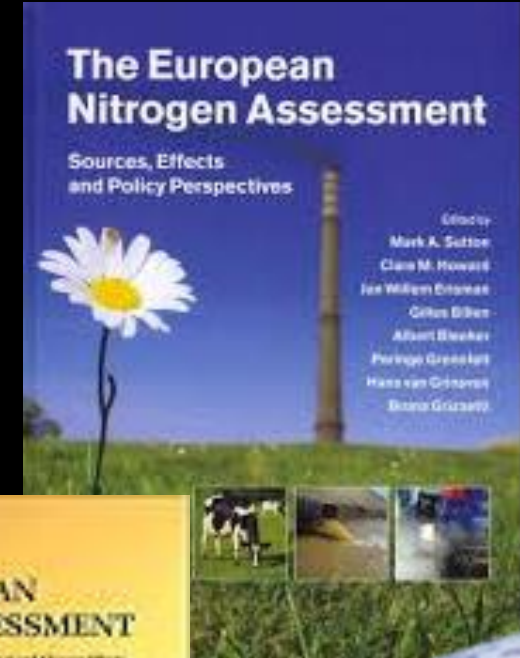
- Taking the science talk to money talk!
- **The Green/Blue Economy**
 - Fertilizer saving – increased efficiency: **US\$23 bn/yr**
 - Environmental and human health benefits: **US\$160 bn/yr**
 - Implementation investment costs: **US\$12 bn/yr**
- **Net Benefit: US\$170 bn/yr**

Source: Our Nutrient World (2013)



Countries stepping up!

- Countries are committing to the **“nikking the nutrient nuisance”**
 - UN Environment Assembly resolutions on pollution - air, soil, water, oceans
 - Emerging commitment from South Asia on addressing N
- Global Nitrogen Assessment under GEF-INMS
 - Experiences from regions - Europe and India
- **Inter-Convention Coordination Mechanism???**
 - Harmonize global coordinated action



For more information:

GEF Global Nutrient Cycle Project

Global Programme of Action, UN Environment

<http://nutrientchallenge.org/>

GEF Toward an International Nitrogen Management System

Centre for Ecology & Hydrology, UK

<http://www.inms.international/>



**Centre for
Ecology & Hydrology**

NATURAL ENVIRONMENT RESEARCH COUNCIL

