AGROECOLOGICAL INDICATORS OF CROPPING SYSTEMS: NUTRIENT BUDGETS IN THE SUD MILANO AGRICULTURAL PARK (NORTHERN ITALY)

L. Bechini[1], M. Penati[2], I. Zanichelli[2]

[1]DiProVe, University of Milano, Via Celoria 2, 20133 Milano, Italy, luca.bechini@unimi.it
[2]Parco Agricolo Sud Milano, Via Pancrazi 10, 20145 Milano, Italy

Introduction

Non-model-based agroecological indicators are nowadays proposed as tools with low data requirement for interpreting and integrating information about cropping and farming systems, and to draw conclusions about their sustainability (Bockstaller et al., 1997). In particular, nutrient budgets identify risks of nutrient accumulation/depletion in soil or nutrient losses to the environment (Oenema et al., 2003). Calculations of nutrient budgets for a high number of farms require large amount of data. These can be derived from official livestock and land use databases, supplied with proper estimates of missing data (e.g. Sacco et al., 2003; 870 farms), or from direct interviews to farmers (e.g. Swensson, 2003; 138 farms). Here we present an integration of the two methods; we used the Agricultural Information System for the Parco Agricolo Sud Milano (SITPAS), which integrates a great quantity of data about agriculture and environment for this regional agricultural metropolitan park (PASM).

Materials and methods

The PASM covers an area of 47,000 ha surrounding the town of Milano. The SITPAS database (Bechini and Zanichelli, 2000) contains detailed information about crop management and livestock, and was built upon official databases and direct interviews to all farmers of PASM. Several data (crop management in particular) are georeferenced at the cadastral parcel scale. From the SITPAS database we extracted: i) for each crop: yield; amounts of mineral fertilizers applied and their nutrients concentrations; fate of crop residues; ii) for each farm: number of heads in each animal group and their average weight. From the literature we derived: i) for each crop type: nutrient concentrations in the useful product at current production level, residues produced and their nutrient concentrations, harvest index; ii) for each type of animal breeding: amount of nutrients in manures (kg nutrients t^{-1} live weight $year^{-1}$). Missing data were estimated when possible, by using average crop yields and/or average crop humidity; in other cases (amounts of fertilizers applied or number of animals or their weight not specified), the whole crop or rotation or farm was discarded from the analysis. As a result of this screening process, we obtained a total of 625 farms, 1113 rotations, 2677 crops, 58 crop types (for a subset of crop types, see the table), covering 29,396 ha (83% of PASM agricultural area). On these bases, it was possible to estimate the components (all expressed in kg ha^{-1}) of the "soil surface budget" (Oenema et al., 2003) for each crop: $S = F + R_{in} + M - R_{out} - U$, where: S = nutrient surplus, F = amount of nutrients applied with mineral fertilizers, R_{in} = amount of nutrients returned to soil with residues from previous crop in rotation, M = amount of nutrients applied with liquid and solid manures, R_{out} = amount of nutrients removed from soil with crop residues, U = crop uptake (nutrients removed from soil with useful product). Nutrients contained in irrigation water, atmospheric deposition and ammonia volatilization were not considered. Positive values of S indicate nutrient accumulation in soil and/or nutrient losses, negative values indicate nutrient depletion from soil.

Results and discussion

The average surpluses (Table 1), not high when considering the whole area surveyed, are larger for spring crops, particularly for maize, while for winter cereals they are close to zero or even negative. Therefore, on average, environmental risk is moderate or very low. Analysis of N budget components show that animal farms, compared to non-animal farms, compensate the higher nutrient inputs due to manures with less mineral fertilizers and higher crop uptakes; this explains the small difference between their surpluses (S=28 and 2 kg N ha^{-1} respectively). The average values are affected by large variability (there are cropping systems with surpluses and others with deficits); this requires to point the attention on farms and rotations with the highest surpluses, which can also be identified on a map (see an example in Figure 1). Compared with Sacco et al. (2003), who described an area in northern Italy with intensive animal husbandry, our calculated surpluses are much lower, due to smaller nutrient loads from livestock.

Table 1 – Nutrient surpluses (kg ha^{-1}) for the most important crop types

Crop	Area (ha)	N avg.	N sd	N 5°	N 95°	P avg.	P sd	P 5°	P 95°	K avg.	K sd	K 5°	K 95°
Maize	11368	99	167	-123	440	28	67	-31	154	84	149	-112	375
Rice	7588	29	69	-61	149	9	20	-18	47	79	78	-30	218
Permanent meadows	3057	-101	149	-265	185	-12	42	-55	74	-82	157	-256	243
Soybean	2104	-168	58	-246	-70	-15	13	-28	9	-7	75	-88	137
Barley	1088	-13	137	-137	207	3	43	-21	66	53	122	-79	271
Italian ryegrass	936	36	134	-90	325	6	37	-23	80	9	137	-138	298
Winter wheat	872	-58	125	-248	79	-7	38	-35	38	-1	102	-106	195
Rape	465	-53	62	-122	71	-17	8	-29	2	-15	41	-73	55
Rotated meadows	459	-110	115	-296	88	-17	28	-54	29	-79	116	-261	114
Alfalfa	324	-241	130	-396	-2	-13	32	-40	57	-84	139	-241	143
Set-aside	214	51	31	22	89	9	5	4	17	91	55	38	189
Other crops	921	-36	138	-248	201	2	46	-35	65	5	136	-150	271
All Park	29396	17	159	-213	278	10	50	-42	89	42	140	-179	296

Avg. = average; sd = standard deviation; 5° and 95°=5th and 95th percentile

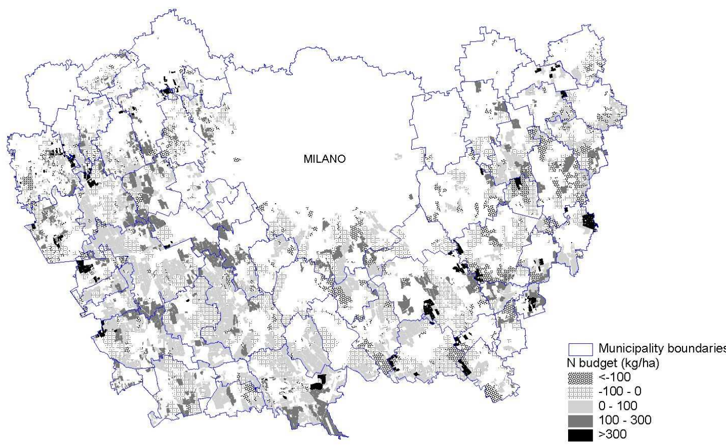

Figure 1 – Nitrogen budget (kg N ha^{-1}) for the entire Park

Conclusions

These results show the power of simple but significant indicators in describing environmental impact of agriculture. Additional indicators are being calculated for phosphorus (Bechini et al., 2004) and organic matter.

References

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