The footprint of organic farms

some ecological indicators to evaluate it

scientific basis and possibility of application

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Introduction

As recently stated by IFOAM, with the term “organic farming” we can understand the management strategy which aims to achieve three sets of goals:

- a) to exploit the natural levers of production, in order to preserve the agro-ecosystem and to maintain the integrity of its functional complexity for the future generations;
- b) to provide wholesome products in adequate quantities to satisfy the needs of society;
- c) to ensure stable and satisfactory incomes to the various actors in the whole food chain (production-processing-consumption), according to the paradigm planet / people / profit, which summarizes the elements of this conception.

Why the agro-ecological indicators

Comparing to the general problem of agro-environmental assessment of agricultural systems, some specific needs arise if we consider the sustainable issues, such as:

- developing tools that enable the transfer of knowledge from research to the farmers, and to the public management officials
- summarize and systematize the knowledge for different production systems (e.g. animal husbandry, horticulture)
- minimize the effort required for data acquisition
- simplify the evaluation, to make them the most transparent and robust

The DPSIR scheme

The EU has recently defined a set of agro-ecological indicators (AEI), which can be classify as follow:

- Indicators of *Driving forces*, which can be useful in quantifying human activities and behaviors related to individual and social needs, economic and productive processes and consumption which causes environmental pressures;
- Indicators of *Pressure*, which can be used to quantify the result of the presence of driving forces in the affected area;
- Indicators of *State*, which quantify the environmental quality or features to be protected and preserved endangered by pressures;
- Indicators of *Impact*, characterizing the state of the significant changes that appear as alterations in the ecosystems;
- Indicators of *Response*, which can be able to quantify the changes occurring as a result of actions addressed to face the impacts.

The survey INDIA

Agro-ecological indicators for organic agriculture

The purpose of the survey

The survey INDIA was carried out by the Department of Food Crops (DiProVe) of the Faculty of Agriculture – State University of Milan, and financed by the Agriculture Department of the Lombardy Region.

The purpose of this survey was to identify some indicators of crop production in order to be able to compare different farms regarding their sustainability level and to provide farmers with a simple tool for assessment of their management.

The agro-ecological indicators can be used to calculate the footprint of the organic farms and to make a comparison between them and with other types of farms (conventional and/or sustainable).

How the survey was carried out

The method of calculation of the indicators used corresponds to that developed for a similar research “Application of Agro-Ecological and Economic Indicators in Northern Italy” conducted by DiProVe on conventional farms of the “Sud Milano Agricultural Park” – an area located south of Milan.

- Some factors, like chemical pesticides or chemical fertilizers, were not considered in this survey because they are not applicable in the context of organic farming.
- All the survey was made at "farm level" and consider only the crop production.

The sample selection

The sample for the survey was selected from the official database of organic farms in the region of Lombardy, in the northern part of Italy, subjecting the initial scope to a double selective filter:

- only entirely organic farms were selected. Partially conventional farms have been excluded: that ruled out the possibility of considering “parallel crops”;
- only those farms that had completed the conversion period were selected.

This allowed us to circumscribe the scope and to provide uniform data analysis.

The selection criteria

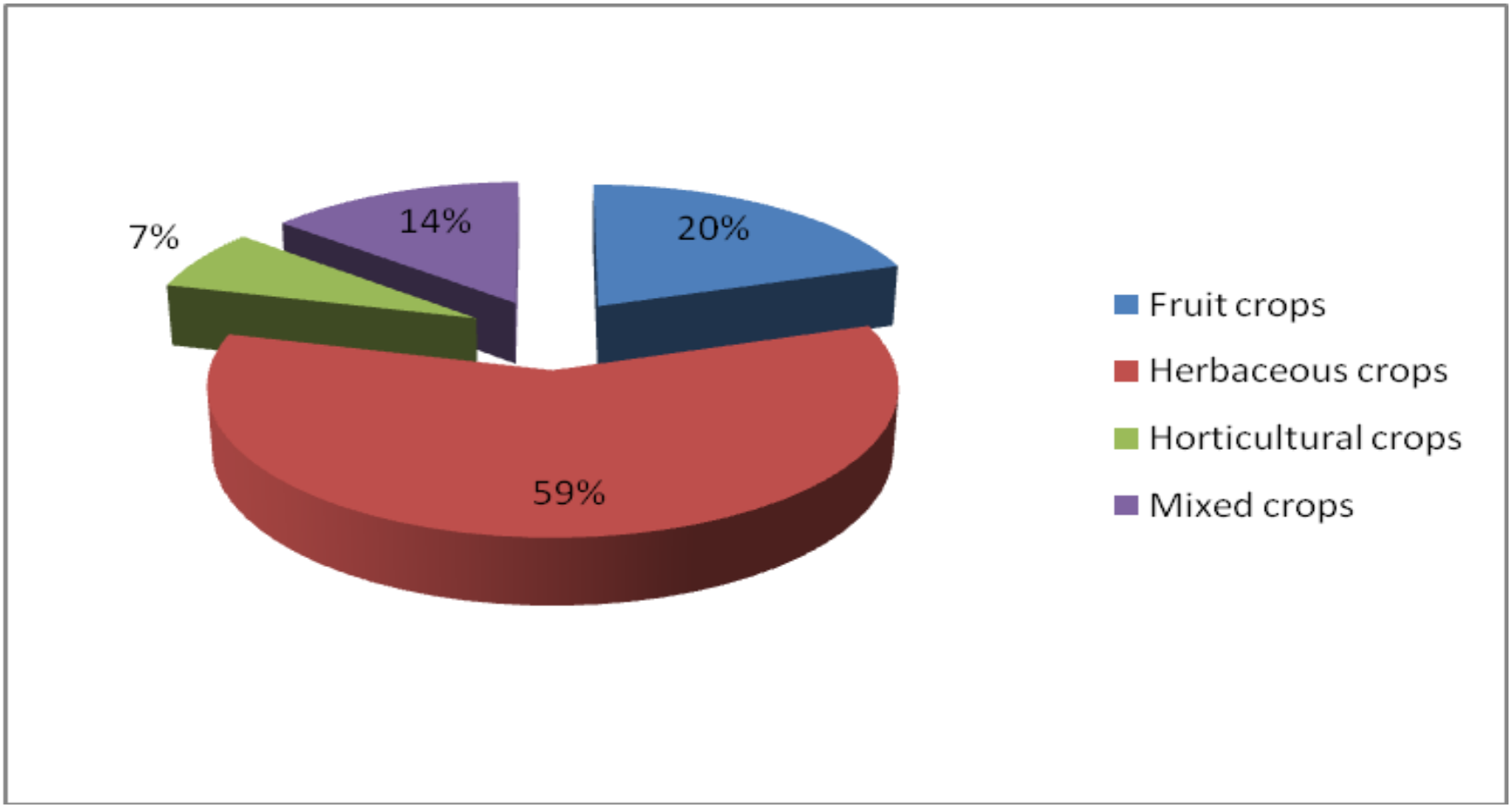
The sample was chosen according to a matrix that interlaces two selection criteria:

- the territorial representation: it was considered the "territorial weight" in terms of number of farms present in the various provinces;
- the representativeness of ordering crops: it was considered the number of organic farms by type of cultivation system according to the official national classification.

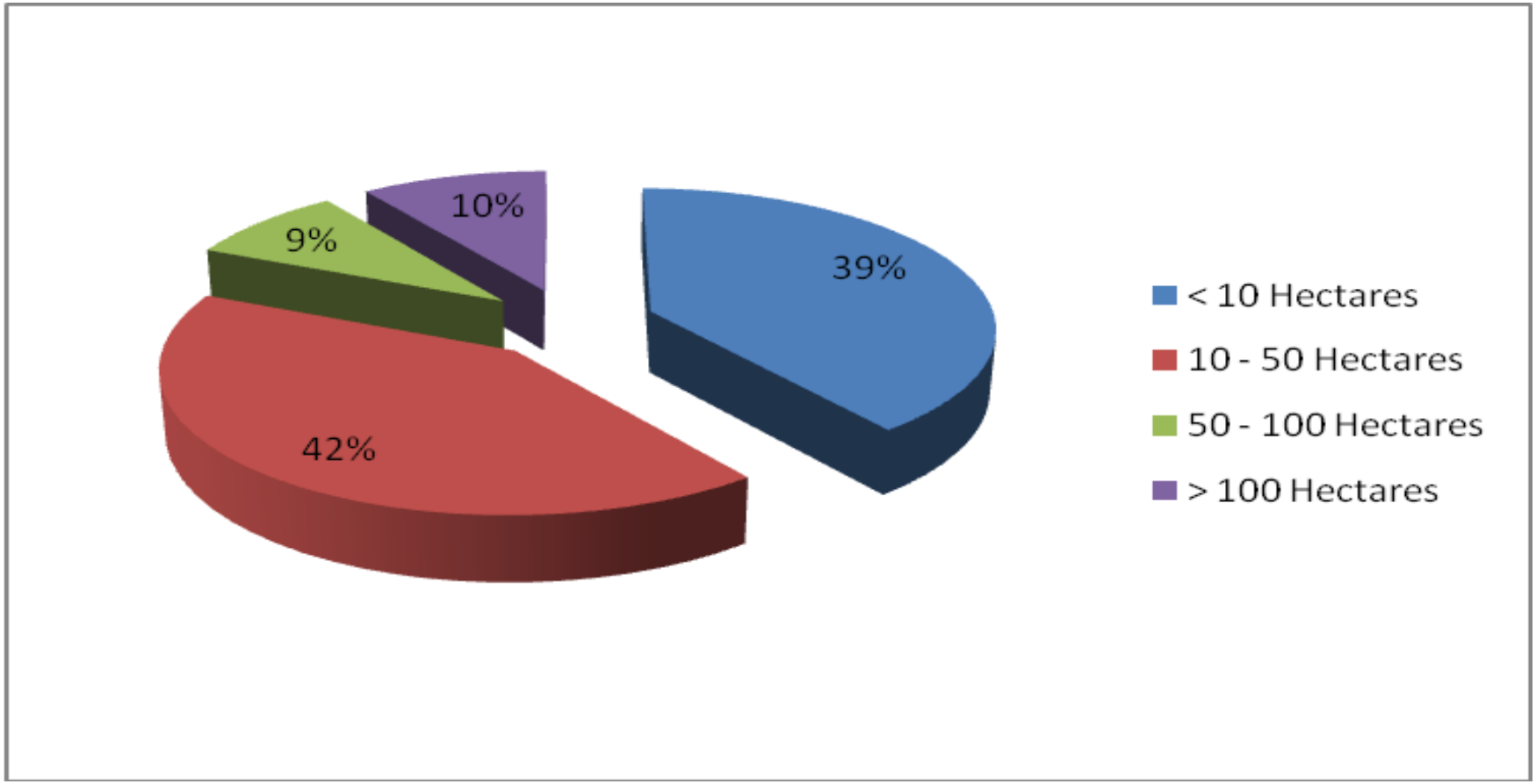
Altogether, 81 farms were selected.

The survey is based on data on crops grown in 2007.

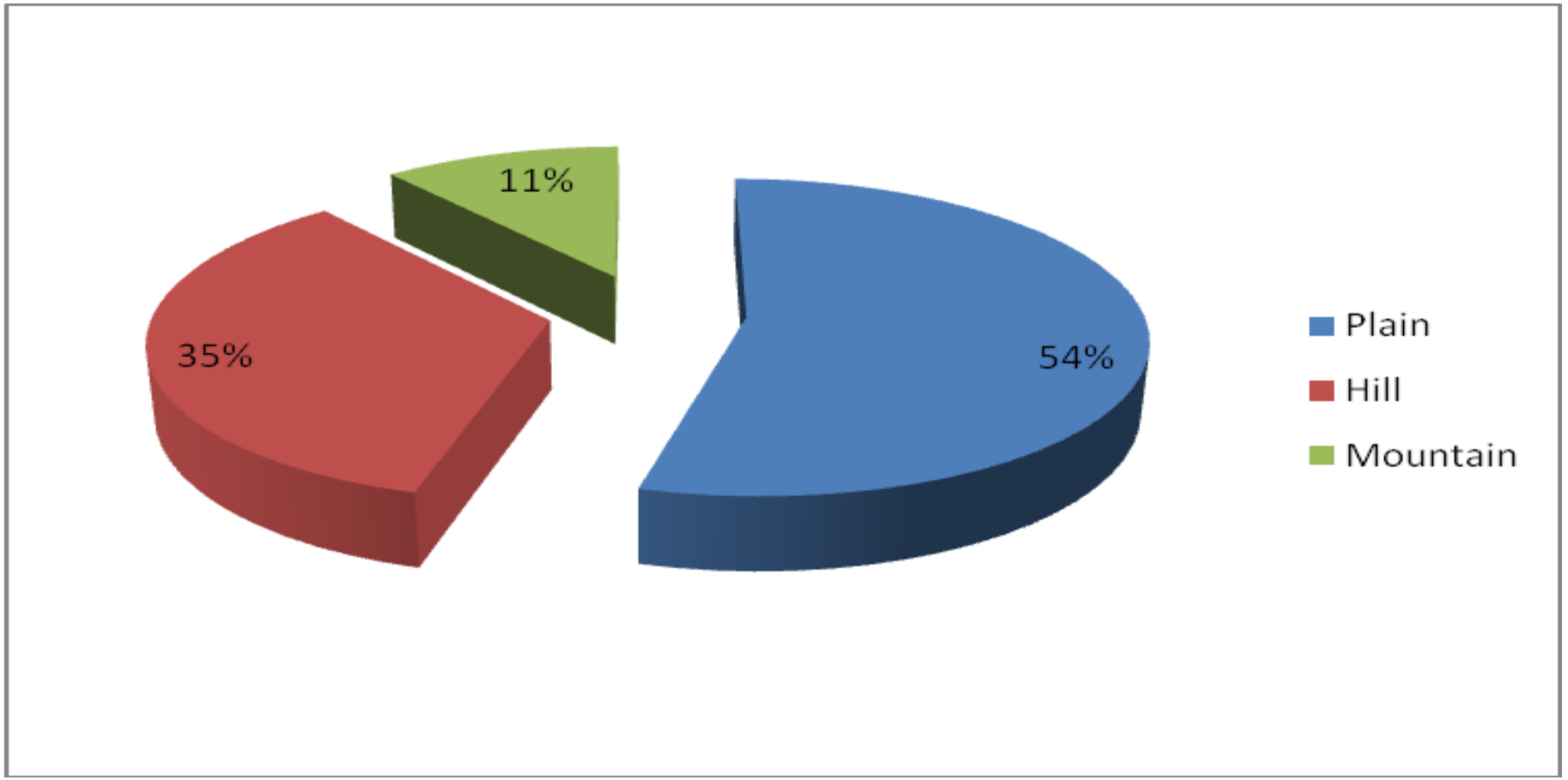
Share of the farms in various cropping systems



Share of the farms in various groups of acreage



Share of the farms in different land types



The agro-ecological indicators used

Altogether, seven agro-ecological indicators were considered in this survey (a-g). In addition to energy input and output, N and P balance the amount of hedges and total workload were assessed.

a. Hedges and Rows
b. Energy input
c. Energy output
d. Energy O/I ratio
e. N balance
f. P_2O_5 balance
g. Works unit per ha

The possible comparisons

a. Hedges and Rows
b. Energy input
c. Energy output
d. Energy O/I ratio
e. N balance
f. P_2O_5 balance
g. Works unit per ha

The first six indicators (a-f) were calculated also in the previous survey on conventional farms “Application of Agro-Ecological and Economic Indicators in Northern Italy”, even if mainly at crop level.

Furthermore, some data are available on the workers employed in different types of farms (national and regional statistics, economic and social surveys).

All these are **Indicators of State**.

Calculation of the indicators

In the next slides the method of calculation of each indicator is highlighted.

For energy indicators, the specific energy equivalent (SEQ) of various factors included was used to calculate the energy input or output.

The SEQ is the amount of energy stored or embedded in a factor per unit of volume, or per unit of mass, depending on the context, and is expressed in MJ * UM^{-1}.

UM = Unit of Measurement.

Calculation of the indicators
a. Hedges and Rows

was measured as meters of hedges and rows / ha of ASU

ASU = Agricultural Surface Used. It excludes the unproductive surface, as buildings, ditches.

Calculation of the indicators
b. Energy Input

was measured as the sum of:

- **Machining:** input fuel consumption (l) * SEQ + lubricants (kg) * SEQ
- **Phytosanitary treatments**: pesticides used (kg) * SEQ - *only organic pesticides were considered*
- **Mineral fertilizer**: Mineral fertilizers used (kg) * SEQ (default values: kg N contained in 1 kg of fertilizer) – *not considered*
- **Organic Fertilizer:** Organic Fertilizer used (kg) * SEQ (default values: kg N contained in 1 kg of fertilizer / 2)
- **Energy embedded in machinery** (MJ * l^{-1} fuel consumed
- **Other materials**: quantity used (UM) * SEQ

N.B.: energy embedded in every material has been considered, according to the values of Table show in the next slide

Energy embedded in the productive factors

Materials	UM	Energy embedded (MJ * UM^{-1})	Source
Surface irrigation	m^3	0,045	estimated
Sprinkler system irrig.	m^3	0,346	Ribaudo, 2000
Electricity	kWh	3,6	calculated
Diesel fuel	l	36,4	Patzek, 2004
Lubricants	kg	83,7	Dalgaard et al., 2000
Energy embedded in machinery	MJ/l of diesel consumed	12	Dalgaard et al., 2000
Harvest boxes (wood)	kg	2,5	estimated
Harvest boxes (plastic)	kg	125,6	estimated
PE for mulching	kg	125,6	estimated
Galvanized iron wire	kg	63	estimated
Chemical herbicides	kg	288	Biermann, 1999
Chemical fungicides	kg	196	Biermann, 1999
Chemical insecticides	kg	237	Biermann, 1999
Organic fungicides	kg	108	estimated
Organic insecticides	kg	50	estimated
String	kg	10	estimated
Plastic strings	kg	125,6	estimated
Mineral NH_4 fertilizers	kg FU (Fertilizer Unit)	39	Kongshaug, 1998
Mineral ureic fertilizers	kg FU (Fertilizer Unit)	48	Kongshaug, 1998
Mineral NO_3 fertilizers	kg FU (Fertilizer Unit)	32	Kongshaug, 1998
Mineral phosphatic fertilizers	kg FU (Fertilizer Unit)	4	Kongshaug, 1998
Mineral potassium fertilizers	kg FU (Fertilizer Unit)	5	Kongshaug, 1998
Vineyard stakes (wood)	kg	2,5	estimated
Seeds of winter cereals	kg	31,4	estimated
Seeds of corn	number of seeds * 1.000	20,376	estimated
Seeds of rice	kg	31,4	estimated
Seeds of forage grasses	kg	31,4	estimated
Seeds of pulses (soia, beans)	kg	40,4	estimated

Calculation of the indicators
c. Energy Output

was measured as the sum of :

- **Total Biomass produced by all the crops = for every crop:** total ha cultivated * kg / ha dry matter produced * SEQ + kg / ha dry matter of secondary products (e.g.: straw) * SEQ
- **Waste** (sold or otherwise transferred out of the farm) = kg * SEQ
- **Vegetal byproducts** (sold or otherwise transferred out of the farm) **=** kg dry matter of byproducts * SEQ
- **Animal products, raw or processed** (sold or anyway transferred outside of the farm**) =** kg / ha dry matter * SEQ

N.B.: *default values* used for the energy embedded in the final products are taken from the official table of food composition of INRAN (National Research Institute for Food and Nutrition

Calculation of the indicators
d. Energy Output/Input ratio

Energy Output / Energy Input

Calculation of the indicators
e. N balance

was calculated as: **N Input - N Output**

***Input** = Sum of the following:*

Organic fertilizers used = kg * default values (kg N contained in 1 kg of fertilizer) OK

Mineral fertilizers used = kg * SEQ * default values (kg N contained in 1 kg of fertilizer) - *not considered*

Biological nitrogen fixation = crop * cultivated hectares * default values (kg N fixed by the crop every year)

Atmospheric nitrogen fixed = 15 kg / ha * y

***Output** = Sum of the following:*

kg N in the sewage (sold or otherwise transferred from the farm) kg * default values (kg N contained in 1 kg of sewage)

Plant products, raw or processed (sold or otherwise transferred from the farm) **= for every crop:** total ha cultivated * kg / ha dry matter produced * default values (kg N contained in 1 kg of vegetal product, raw or processed, rejects included)

Animal products, raw or processed (sold or anyway transferred outside of the farm) **=** kg dry matter produced * default values (kg N contained in 1 kg of animal product, raw or processed, rejects included)

Calculation of the indicators
f. P_2O_5 balance

was calculated as: **P_2O_5 Input - P_2O_5 Output**

***Input** = Sum of the following:*

Organic fertilizers used = kg * default values (kg P_2O_5 contained in 1 kg of fertilizer)

Mineral fertilizers used = kg * SEQ * default values (kg P_2O_5 contained in 1 kg of fertilizer)

***Output** = Sum of the following:*

kg P_2O_5 in the sewage (sold or otherwise transferred from the farm) kg * default values (kg P_2O_5 contained in 1 kg of sewage)

Plant products, raw or processed (sold or otherwise transferred from the farm) **= for every crop:** total ha cultivated * kg / ha dry matter produced * default values (kg P_2O_5 contained in 1 kg of vegetal product, raw or processed, rejects included)

Animal products, raw or processed (sold or anyway transferred outside of the farm) **=** kg dry matter produced * default values (kg P_2O_5 contained in 1 kg of animal product, raw or processed, rejects included)

Calculation of the indicators
g. Work units per hectares

was measured as annual work = h / ha * y

Average values for the ecological indicators of the cropping systems

Indicators	Hedges and Rows	Energy Input	Energy Output	Energy O/I ratio	N Balance	P_2O_5 Balance	Work Unit per hectare
Cropping systems	m/ha	GJ/ha	GJ/ha		kg/ha	kg/ha	h/ha
Fruit crops (16 farms)	75,86	12,46	56,77	5,39	99,07	46,46	690,26
Herbaceous crops (48 farms)		13,28	164,64	14,93	134,93	-2,17	276,97
Horticultural crops (6 farms)		32,88	65,39	3,35	15,75	-23,25	65,56
Mixed crops (11 farms)		12,54	106,79	10,18	82,97	2,61	460,73

Comments to the results

The survey has shown the usefulness of the indicators used

The results of calculations show that it is possible to distinguish between the management of the farms.

No outliers were found and the values of the indicators are within the range. The differences between the different results are all explicable on the basis of cropping systems, groups of acreage and different land types to which the different farms belong.

All the results of the survey were published in Bocchi S., Bechini L., Spigarolo R. “Indicatori agroecologici per l’agricoltura biologica” - Research handbook of Regione Lombardia n. 97, march 2009.

A tentative of comparison

At the moment, it is not possible to drive a significant comparison between organic and conventional farms: a similar research “Application of Agro-Ecological and Economic Indicators in Northern Italy” conducted by DiProVe on conventional farms of the “Sud Milano Agricultural Park” was carried out on a different basis of data, mainly at crop level.

Anyway, the table in the next slide show three indicators (Energy input, Energy output and Energy O/I ratio) calculated at crop level for the main herbaceous crops, with the same formulas of the India survey.

Average values for the ecological indicators in conventional farms

Crops	Corn	Rice	Wheat	Barley	Permanent meadows	Soybean	INDIA Herbac. crops
Indicators							
Energy Input (GJ/ha)	27,3	22,7	16,4	12,0	13,1	11,6	13,28
Energy Output (GJ/ha)	220,3	138,2	156,0	164,3	139,3	139,3	164,64
Energy O/I ratio	8,5	6,2	10,1	14,5	10,6	10,6	14,93

Perspectives

Now we are testing a website in which all farmers can input their data about the consumption of materials, fertilizers, fuel and so on (the same parameters of the survey).

The software calculate their indicators and compare them with the averages found in the survey. So the farmers can very easily compare their management system with simple parameters (the indicators), and try, e.g., to reduce their energy inputs, or to improve the N balance.

The website system memorize their data, so, 1 year later, submitting the new data after the change, they can evaluate their success. The website will be ready at least next February.

Implementation of the survey

- The survey will be implemented with another step. In the second part of the survey, that will be carried out next year, also the livestock indicators will be considered and a comparison with conventional and/or sustainable farms will be developed.
- Furthermore, we will try to find some parameters in order to realize a significant comparison between conventional and/or sustainable farms.

GPP and agro-ecological indicators

The first data from a recent survey carried out by the IT group of iPOPY show that in the call of tenders for school canteens in Italy one of the most frequent requirement to procure products in short supply chain, highlighting them as “zero km”.

This request, however, is ambiguous and not allowed by European rules on transparency in tendering.

For this reason, in a recent conference held in Bologna, Italy, in September 2009 about the quality in school canteens, the IT group of iPOPY proposed to introduce the calculation of the footprint as an objective requirement to assess the ecological impact of the cropping systems and of the supply chain instead of using the zero km requirement.