Sustainability assessment of stockless organic farming system with agro-ecological and socio-economic indicators in Italy

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Abstract

Is organic agriculture sustainable? For which aspects? These research combine the agroecological with the socio-economic dimension of sustainability. It has been performed in the three years 2006/08, over 12 organic farms located in 6 regions of central and northern Italy. To assess agricultural sustainability at farm level the following environmental subsystems were identified: the physical system (soil and water) and biological (flora and fauna) and the production system (crop rotation and energy). For each of these systems different agro-ecological indicators are processed to evaluate a specific attribute of the system and its critical points. The socio-economic indicators evaluate structural and economic performance of the farms. Agro-ecological and economic indicator were integrated into a Global Sustainability Index (GSI), able to synthesize the information contained in the multiple-derived variables, ranging from 1 to 2. The indicator values were first converted into a sustainability score applying continuous non-linear sustainability functions. Consequently, stratification was performed on three levels of sustainability: weak, intermediate, strong. Results shown that not all the farms reach satisfactory level of sustainability.

1. Introduction: the search for sustainability

In the face of increased food production required to meet the needs of a growing world population, environmental damage caused by agriculture are well documented and range from air pollution (i.e. greenhouse gases), soil degradation (erosion, loss of fertility, salinization, etc.), pollution of water caused by the use of fertilizers and pesticides and destruction of aquatic ecosystems, loss of biodiversity at all levels. Even from an economic and social point of view agriculture created many imbalances. Inputs as well as costs increased and in return the increased productivity do not create greater profit for the producers as the efficiency of fertilizers decreased. The number of farms in developed countries have fallen dramatically over the past 50 years and the number of people employed in agriculture is at historic lows. In Italy from 2000 to 2010, 775,033 farms closed (- 32,2%) (ISTAT 2011) and in 2010 only 3,8% (of total occupied) are occupied in the agricultural sector (Eurostat). The effect on health are also dramatic: pesticides are known to cause at global level 26 million human poisonings per year and 220,000 deaths (Richter, 2000).

There is a global need for a more sustainable agriculture. Organic farming is considered as one of these and of the many alternative forms of agriculture is the only one that is certified and recognized worldwide. The Codex Alimentarius Commission at point 5 states that: “Organic Agriculture is one among the broad spectrum of methodologies which are supportive of the environment. Organic production systems are based on specific and precise standards of production which aim at achieving optimal agroecosystems which are socially, ecologically and economically sustainable.” (Codex Alimentarius, 2004, p. 4). According to the proposed Codex definition, "organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system." (FAO, 1999).

However criticism of the organic sector is not lacking from those who see it as a sector agro-industrial and business driven like the large-scale conventional agriculture as well as too bureaucratic for small farms, both by others who consider it not very productive and suitable. IFOAM have reacted providing a new definition[1] of organic agriculture and approving the Organic Principles of health, ecology, equity and care (IFOAM, 2005) that should guide and inspire the application of Organic Standards and involve the pursuit for purposes of economic, social and ecological farming which is not resolved in the adoption of simple techniques conform to the dictates of the regulations.

Organic agriculture is practiced in 160 countries and 37.2 million hectares of agricultural land are managed organically by 1.8 million farmers. The global sales of organic food and drink reached 54.9 billion US dollars in 2009 (Willer and Kilcher, 2011) mainly for their reputation to be environmental friendly and healthy products. In Italy the area managed under organic farming is 1,113,742 hectares with 47.66347.663 operators (SINAB, 2010).

To ensure if organic farming is the answer to sustainability problem it has to be evaluated with indicators adapted to locally situation. Methodologies for assessing agricultural sustainability are many and they use different matrices of indicators (Belle and Morse, 1999) at both global (OECD,1999), national (INEA, 2008) and farm level (Nicholls et al. 2004). Agricultural sustainability is very complex issues as agriculture is multifunctional (production of goods and services) and sustainability is a multi scale and multi-issues terms often in contrast between them and it need a multi-dimension (environmental, economic, social and cultural) and multi-criteria assessment and set of indicators taking into account different level of analysis (farmer, consumers, governments, international agreements). These research combine the agroecological with the socio-economic assessment of organic farms in Italy.

[1] “Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved” http://www.ifoam.org/growing_organic/definitions/doa/index.html)

2. Materials and methods

2.1 Case studies

The assessment of sustainability was performed in the three years 2006/08 on a limited sample of organic farms, as suggested by Eckert et al. (2000) in studies of sustainability in agriculture, that have joined the project SimBioVeg (Systems and methods of organic farming to improve the quality of crops and the environment - www.simbioveg.org). Twelve organic mixed farms in six regions of central and northern Italy (Lazio, Umbria, Tuscany, Emilia Romagna, Veneto, Lombardy): 11 mainly horticultural farms engaged in direct market and one producing also cereals and grain legumes (tab.1). All the farms adopt the organic method since a long time (more than 10 years), without animal husbandry, they are of small size and with a large number of crops of particular value, such as products of local varieties and PDO (i.e. “fagiolina del Trasimeno”, a local bean).

Table 1. Characteristics of the case studies

Cropping systems	n. of farms	UAA (ha)	N of crops (average)
Cereals	1	6,8	4
Horticulture	11	9,6	16
Weighted average	12	9,4	15

2.2 Assessing agro-ecological sustainability

To assess the sustainability of organic farming systems with regard to agro-environmental aspect, a methodology based on indicators of sustainability is adopted (Pacini et al., 2009; Vazzana and Migliorini, 2007; Vazzana et al.1997; Vereijken, 1997). For the farm analysis, the following information, which are acquired through interviews with farmers, business documents and maps, data collection and analysis, are collected: i) agro-ecological characterization of the case study, through the description of climate and other characteristic (i.e. topography, land use, soil classification, ecological infrastructure, water bodies), which also leads to the determination of homogeneous farm areas; ii) quantification of the production processes of business management, namely the determination of inputs and outputs of energy and macronutrients (i.e. machinery, seeds, fertilizers, pesticides, water) which can be conducted at the field level (specific crop input and output) or at the farm level (e.i. electricity, fuel); iii) choice and calculation of indicators of sustainability.
To assess agricultural sustainability at farm level the following environmental sub-systems have been identified: the physical system (soil and water), biological (flora and fauna) and the production system (crop rotation and energy). For each sub-systems, several agro-ecological indicators are processed to assess a specific attribute of the system and its critical points. Each indicator is associated with an optimal value which is derived from literature and adapted to the territorial context (table 2).

2.2.1 Physical system: the soil and water

To assess physical and chemical quality, soil was characterized. In the two of the most representative homogeneous areas soil samples at 30 cm were collected for analysis. With the results of physico-chemical analysis of soil, we calculate the following indices: OMAR (Organic Matter Annual Reserve), TNAR (Total Nitrogen Annual Reserve), PAR (Phosphors Available Reserve), KAR (Potassium Available Reserve),PNL (Potential Nitrogen Leaching), C/N (C/N ratio). To assess the risk of erosion is calculated the SCI (Soil Cover Index) for the Annual period (12 months) or Critical period (the months from November to April) more prone to risks of rain erosion.

2.2.2 Biological system (flora and fauna): landscape and biodiversity

For the assessment of the landscape and planned agrobiodiversity, seven indicators have been calculated: WA (Wood Area), FA (Field Adjacency), CFS (Crop Field Size, FLW (Field Length Width), FD (Field density), VR (variety richness), AVR (Autochthon Variety Richness), EII (Ecological Infrastructure Index). For associated agrobiodiversity, four indicators are calculated: EIR (Ecological Infrastructure Richness), EID (Ecological Infrastructure Diversity, WD (Weed Diversity). The diversity index means the Shannon index (Shannon and Weaver, 1963).

2.2.3 Production system: crop rotation and energy flow

The organization and the choice of production system in time and space is influenced by many factors (i.e. climate, land, soil, technical knowledge, market, culture). And affects all others (biodiversity, soil quality, pathogens and insects, weeds, gross saleable, work). For the evaluation of crop rotation in terms of physical and biological seven indicators are identified : CR (Crop Rotation Length), AS (Adjacency Species), SS (Share Species), SG (Share Group).

The quantification of the energy incoming and outgoing flows allows to determine the output/input budget (Energy Efficiency, EE). For the direct energy inputs, we considered the consumption of fuel, lubricant and electricity at the farm level, for the indirect inputs pesticides, organic fertilizers and seeds have been counted. The outputs have been divided into external production for the market and re-used product in the farm (as seed or green manure). The value of equivalent energy content was evaluated as primary energy, resulting from the sum of the energy cost for the production, transportation, distribution and marketing of the energy "embedded" in the subject (Vazzana et al. 1997; Baldi et al., 1986; Biondi et al.1989; Dalgaard et al., 2001; USDA, 2004; Koga, 2008). The solar energy, the human labour and the energy arising from the production and repair of machines were not counted among the external inputs.

2.3 Assessing socio-economic sustainability

The farms were grouped according to the cropping systems (C - cereal, OR - Horticultural) because it is also indirect expression of the farm structure. During the period of observation, technical and economic data, endowment of capital and machinery and the use of work were collected in the farms. These data were used to proceed and elaborate the economic balance, whose main results are reported in tab. 3 and express succinctly the ability to produce income. The value results is expressed per unit of area (weighted average) for both the cropping systems and the total farms.

The gross output (GO) is the value of farm productions (i.e. cereals, fruits, vegetables) farm processing (i.e. wine, oil), agro-tourism, community services and awards; costs are divided into fixed (FC) and variables (VC): the first includes the cost of individual crops and the cost of specific services, temporary work, while fixed costs include the cost of use of capital, general operating costs and permanent work; the Net Farm Product (NFP) is the richness produced and is calculated by subtracting from GO the costs of crops specific, the depreciation and the taxes; The Net Income (NI) is calculated by subtracting costs (FC and VC) from GO; the Farm Profit (+ /-T) is the reward for assuming the business risk and is calculated by subtracting from the NI the cost of internal resources, owned by the farm; the Profitability of domestic labour is paid hourly of the entrepreneur; the ROE (Return on Equity) represents the overall profitability of the farm and is calculated by dividing the NI to Net Asset (NA).

2.4 The integration of agro-ecological and socio-economic indicators into a Global Sustainability Index

The need to provide a system approach to the analysis of sustainability in the broadest sense, taking into account agro-ecological and socio-economic aspects in functional relationship between them to ensure the protection of the environment and the social cohesion of the territory in which established entrepreneurial activity, justifies the search for a synthetic indicator, called the Global Sustainability Index (GSI), able to synthesize the information contained in the multiple variables derived. To avoid entering redundant information, unbalancing socio-economic analysis in support of the agro-ecological one and risk compromising the effectiveness of the index, a selection of indices were done. The selection criterion is based on a correlation analysis, statistically validated, among the indicators relating to the individual environmental sub-systems described above.

The use of very different variables for the formation of an index, passes through the relativization process with respect to threshold values of each indicator. In this way we obtain a range of variation between zero and plus infinity, where the unit is the limit value above which the degree of sustainability is optimal. Thus, the variation range of interest for specific purposes is concentrated between the threshold values, zero and one.

To avoid incurring compensation phenomenon, typical of the arithmetic mean used in recent studies for the construction of sustainability indexes (Castoldi and Bechini, 2010), the geometric mean has been used as a criterion of aggregation (OECD, 2008). Using this algorithm, the increased variability of the single component of the GSI depress the synthesis result, in accordance with the principle of harmony. However, in a variation range of between 0 and 1 the existence of null values, even for a single indicator, resets the overall result regardless of the values assumed by the other variables. So, in our case, the un-sustainability recorded for a single indicator determines the collapse of the sustainability assessment of the entire system (Nardo et al., 2008).This imposes the need to increase the value by one unit and translate, consequently, the variation range of between 1 and 2.

In summary, the relativization process refers to the following procedure:

If S_{vn} increases with a decrease of V then, $I_n = 1 + (1 - V_n) / (1 - V_{ns})$ where (if $(1 - V_n) / (1 - V_{ns}) > 1$ then $(1 - V_n) / (1 - V_{ns}) = 1$ otherwise $(1 - V_n) / (1 - V_{ns})$)

otherwise, if S_{vn} increases with an increased of V then, $I_n = 1 + V_n / V_{ns}$ where (if $V_n / V_{ns} > 1$ then $V_n / V_{ns} = 1$ otherwise V_n / V_{ns})

otherwise, if optimal S_{vn} is between two limit values of V, then 1, otherwise:

if $V_n < V_{ns\ min}$, then $I_n = 1 + V_n / V_{ns\ min}$

if $Vn > V_{ns\ max}$, then $I_n = 1 + V_{ns\ max} / V_n$

In that varies with between 1 and 2

S_{vn} is where the orientation of the sustainability relative to the *n* variable (V_n); V_{ns} is the threshold value to which it refers V_n; I_n is the result of relativizing the *n* variable.

The analytical expression of the Global Sustainability Index (GSI) is:

GSI= $(n \, I_n \prod) \wedge (1 / n) -1$ where n is the number of variables

With GSI which varies between 0 and 1 and has the form of a semi-parabola having the arc which tends to worsen as the number of variables involved increases (Fig. 1a). The choice of the number of parameters in the calculation of an index of this type is the most significant and critical. This is because the marginal effect associated with the insertion of an additional variable in the model is reduced drastically with increasing the parameters used in conditioning the relative influence of individual components on the result of synthesis. In fact, by deriving the equation of the indicator of sustainability together to identify the weight of the n +1 variable on the total value and, then, placing $(n \, I_n \prod) = X$, we have:

GSI = (a*X)^(1/n+1)-1 where a varies between 1 and 2 from which it follows:

d_{GSI}/dX= a/(n+1)*(a*X)^(-n/(n+1))

From this expression it can be seen as *n* goes to infinity the influence of individual components on the result of synthesis tends to zero (Fig. 1b), justifying the need to use a small number of variables for the purpose. Moreover, the increase of the value of the variable produttoria, reduces the marginal effect of the individual parameters. In the case where more indicators are used in the description of the same phenomenon, those characterized by greater variability, have been selected whenever possible.

The non-linear relationship between the GSI and the variables derivation does not favour an easy interpretation of the results. Consequently there has been a stratification on three levels of sustainability: weak (0), intermediate (1), strong (2) (Table 5, Figure 3). the thirty-and sixty-sixth percentile of the maximum potentially achievable by the indicator was considered as a criterion of division.

3. Results and discussion

3.1 Sustainability assessment of agro-ecological and socio-economic aspects

The results of the sustainability assessment with agro-ecological indicators are presented in tab.2 as the average of the 12 case study. With regard to the soil system, the results show that all indicators, except for the coverage of the soil and the carbon/nitrogen ratio, deviate from the optimum value. The annual SCI (89.45%) and the critical period one (78.32%) are much higher than optimal (50%). This is due to the continuous cycles of horticultural crops and use of green manure. The OMAR is good (2%) since it is a sandy-loam soils but does not reach the threshold value of 2.5%. The values of PAR and KAR are well above the optimal range and given the sandy nature of the soil there is a risk of runoff of phosphorus. The PNL worry as so high values (408 kg) in sandy soils are certainly indicators of risk of run-off of nitrate, especially if irrigated.

Regarding landscape and biodiversity, the evaluation results of these farms show very positive values. Although the presence of the wood's surface is limited (only 3.99% instead of 10%), the farms are very rich in ecological infrastructure (16.68%) with values well above the optimum value (5%). Moreover, the ecological infrastructures are very rich in number of species (56.33) and have a high diversity index (3.38), both well above the limit value (respectively 35 and 2). Indicators of farm structure are not as positive. The plots are not always adjacent (0.45), negative aspect because it disrupts the unit ecological of organic farms (1) especially if neighbouring farms grow conventional horticultural crops, as well as the size and spatial arrangement are not optimal. The highest variety richness (45 varieties of crops) and the presence of autochthon varieties (3.62) show that these farmers adhere to the principles of organic farming and propend for short chain channel (i.e direct sales, buying groups of consumers). Furthermore, there is a high degree of reuse of output (green manure and seeds), further evidence of the tendency to closed loop. The diversity of wild plants in the fields (Shannon index) is less than 2 (1.66) sign that the weed management remains a problem, since two or three species of weeds are generally more present than others.

The results on the evaluation of the crop rotation are optimal and demonstrate that these farms take succession large plans and alternating species and varieties with the main purpose of managing pests and pathogens. The calculation of the energy flows instead shows that these farms are not efficient from the energy point of view. The Energy Efficiency is less than one (0.99 MJ) showing that energy inputs are greater than the output. The EE, compared with those obtained with similar analyzes carried out on organic arable farms in Italy (Migliorini, 2006; Mazzoncini, 2011), show very low efficiency. These results are not due to the high use of external inputs (organic fertilizers, pesticides and seeds), all in all a sign of extensive management. In regard to the output, the productions have very variable yields among the farms but the conversion coefficient for horticultural crops (2.11 MJ/kg) makes the efficiency negative, especially when compared with the conversion coefficient of grain products.

Table 2. Values of the agro-ecological indicator as average of the 12 case studies

System	subsystem	Acronym	Indicator	U.M.	Optimal level	Results (average)	S
Biophysics	Soil and water	SCIa	Soil Cover Index (annual)	% month	x > 50	89,45	8,84
		SCIc	Soil Cover Index (critic period)	% month	x > 60	78,32	12,73
		OMARs	Organic Matter Reserve	%	x ≥ 2,5	2,03	0,85
		TNAR	Total Nitrogen Reserve	‰	x > 1,5	1,22	0,37
		PAR	Phosphate Available Reserve	Ppm	35 < x < 25	81,29	67,97
		KAR	Potash Exchangeable Reserve	Ppm	150 < x < 200	359,78	392,30
		PNL	Potential Nitrate leaching	kg	x < 70	408,00	
		C/N	Carbon Nitrogen ratio	number	9 < x < 12	9,71	1,53
		Texture	soil texture			sandy loam	-
	Biodiversity and landscape	WA	Wood area	% TAA	x > 10	3,99	10,06
		FA	Field adjacency	number	x = 1	0,45	0,28
		CFS	Crop Field Size	Ha	5 > x > 1	5,92	9,50
		FLW	Field Length-Width	number	1 < x < 4	4,91	3,40
		FD	Field Density	number ha-1	max	3,62	2,63
		VR	Variety Richness	number	x > 20	45,00	24,54
		AVR	Autochthon Variety Richness	number	x > 2	3,58	2,57
		EII	Ecological Infrastructure Index	% SAU	x > 5	16,68	12,56
		EIR	Ecological Infrastructure Richness	number	x > 35	56,33	22,75
		EID	Ecological Infrastructure Diversity	number	x > 2	3,38	0,45
Productive	Crop rotation	WD	Weed Diversity	number	x > 2	1,66	0,42
		CR	Crop Rotation	year	x ≥ 6	6,00	0,00
		SA	Specie Adjacency	number	x = 0	0,00	0,00
		SS	Share Specie	% tot. specie	x ≤ 0,167	0,07	0,04
		SG	Share Group	% tot. specie	x ≤ 0,33	0,18	0,12
	Energy efficiency	EE	Energetic Efficiency (output/input)	kg/kg	x > 1	0,99	0,62

The results of the socio-economic analysis are presented in tab.3. The farms are of small size and all cultivate a high number of crops. The setting of production change is in relation to environmental factors and to the endowments of capital, but all are adopt marketing strategies of direct sales. The farms have extensive approach but in the grain farm machinery have more weight and in horticultural farms the financial advances are heavier. In all farms, there are interesting economic results, with positive economic efficiency, even if the vegetables seem more performance and more focused on crop diversification, than in other non-agricultural activities (i.e. agritourism, services). The larger is the farm size, the more the costs decrease: this is due to good technical efficiency characterizing the larger farm, generally provided with a wider and suitable machineries. The NFP has always positive values, that qualifies optimistically organic production method. The NI do not differ significantly between the two production systems, a sign of the relative importance of the cropping system (cash crops vs low income crops) and of the relevance of the supply chain strategies in defining the economic results. In conclusion, all farms show high economic efficiency, but an important role is represented by the type of product, where horticultural crops can benefit compared to other commodities. Moreover, the management ability to relate to the market and to practice short market chain, seems to be more important than yields and EU premiums.

Table 3 Key economic and profitability results (euro).

Indicator	Cereal (euro)	Horticulture (euro)	Average (euro)
Gross output	5,926.00	9,529.00	9,311.00
Crop production %	*59.10*	*85.30*	*84.30*
Fruit production %	-	*2.80*	*2.70*
Processed product %	-	-	-
Services (i.e. agrotourism) %	*32.30*	*4.70*	*5.70*
Non agricultural income %	-	*2.30*	*2.20*
UE subsidies %	*8.70*	*4.90*	*5.00*
Variable Cost (VC)	584.00	1,693.00	1,626.00
Fixed Cost (FC)	3,940.00	6,825.00	6,651.00
Net Farm Product (NFP)	4,206.00	4,764.00	4,731.00
Net Income (NI)	4,206.00	4,292.00	4,287.00
Farm profit (+/- T)	1,402.00	1,011.00	1,035.00
Profitability of domestic labour (€/h)	17.40	8.00	8.20
ROE (NI/NA)	0.138	0.082	0.084

3.2 The selection of Indicators

The statistical analysis of the correlations between the agro-ecological indicators relating to the subsystems considered (data not shown) with the two-tailed t-test reveal the existence of significant links between various indicators. Those results added to the critical issues raised by some indicators (i.e. Crop Rotation has no variability) has led to the selection of 4 variables: the Autochthon Variety Richness (AVR), the Ecological Infrastructure Diversity (EID), the Phosphors Available Reserve (PAR), the Organic Matter Annual Reserve (OMAR), the Energy Efficiency (EE).

Table 4 Selected socio-economic indicator selected for the GSI

System	subsystem	Acronym	Indicator	U.M.	Optimal level	Results (average)	S
Productive	socio-economic	RN/ULUF	Net income per hour of family labour	€/h	x > 7,38	17,05	12,52
		VD	Direct sale	%	x > 80	0,78	0,28
		SERV	Services	-	x = 1	0,38	0,47
		ULF/ULT	the % of family labour on total labour	%	x < 0,58	0,85	0,21

The selected socio-economic indicators are presented in (Tab. 4) show farm with an average profitability per hour of unpaid work well above the threshold value (17 €/ULUF) revealing the existence of viable and dynamic businesses. This is confirmed by the marketing channel mainly oriented to direct sale (78%). However, the lack of services (only one in three delivery services adjuvant agricultural activity) often reflects an insufficient appreciation of landscape hampered by the need to cope with major investment plus an uncertain outcome. This situation has a direct impact on the social aspect, denouncing a low use of off-farm work (0.85 ULF/ULT).

3.3 The GSI

The Global Sustainability Index (GSI) refers to the selection of 4 socio-economic and 6 agro-ecological relativized Indicators (In) and vary between 0 and 1 (tab.5). The average GSI for the 12 case studies is 0,49 with a maximum value of 0,87. The tree level of GSI and the relativized Indicators are presented in tab. 6 and fig.2: weak (0), intermediate (1) and strong (2) sustainability. The farms are almost equally distributed in the three level of GSI. In particular the most represented group is the intermediate sustainability (5 case studies) and the weak is the less populated with 3 case studies. So, as visualized by the fig.2, the general level of sustainability is high. There are Indicators that have better scores that others. In particular the Icr (crop rotation) have the maximum value (1) in the three group. While the Iulf/ult have the lowest total value (0,86) differentiating the three group.

Table 5 Average, minimum and maximum value and standard deviation of the Global Sustainability Index and the 10 primitive indicators (In)

	Average	*Min*	*Max*	*Relative Standard Deviation*
GSI	0,49	-	0,87	0,21
I rn/ulf	0,75	-	1,00	0,25
I ulf/ult	0,31	-	1,00	0,30
I vd	0,78	0,12	1,00	0,14
I serv	0,38	-	1,00	0,34
I ee	0,77	0,16	1,00	0,17
I avr	0,79	-	1,00	0,21
I eii	0,89	0,20	1,00	0,14
I omar	0,75	0,45	1,00	0,10
I cr	1,00	1,00	1,00	-
I par	0,56	0,14	1,00	0,20

Table 6 The tree level of GSI: weak (0), intermediate (1) and strong (2) sustainability, farms group and the primitive indicators

GSI	Number of cases	Irn/ulf	Iulf/ult	Ivd	Iserv	Iee	Ieii	Iomar	Iavr	Icr	Ipar
-	3	-	-	0,93	0,33	0,66	1,00	0,67	0,83	1,00	0,57
1	5	1,00	0,30	0,72	0,20	0,66	0,84	0,83	0,60	1,00	0,50
2	4	1,00	0,56	0,75	0,63	1,00	0,87	0,70	1,00	1,00	0,64
TOT	12	2,00	0,86	2,40	1,16	2,32	2,71	2,20	2,43	3,00	1,71

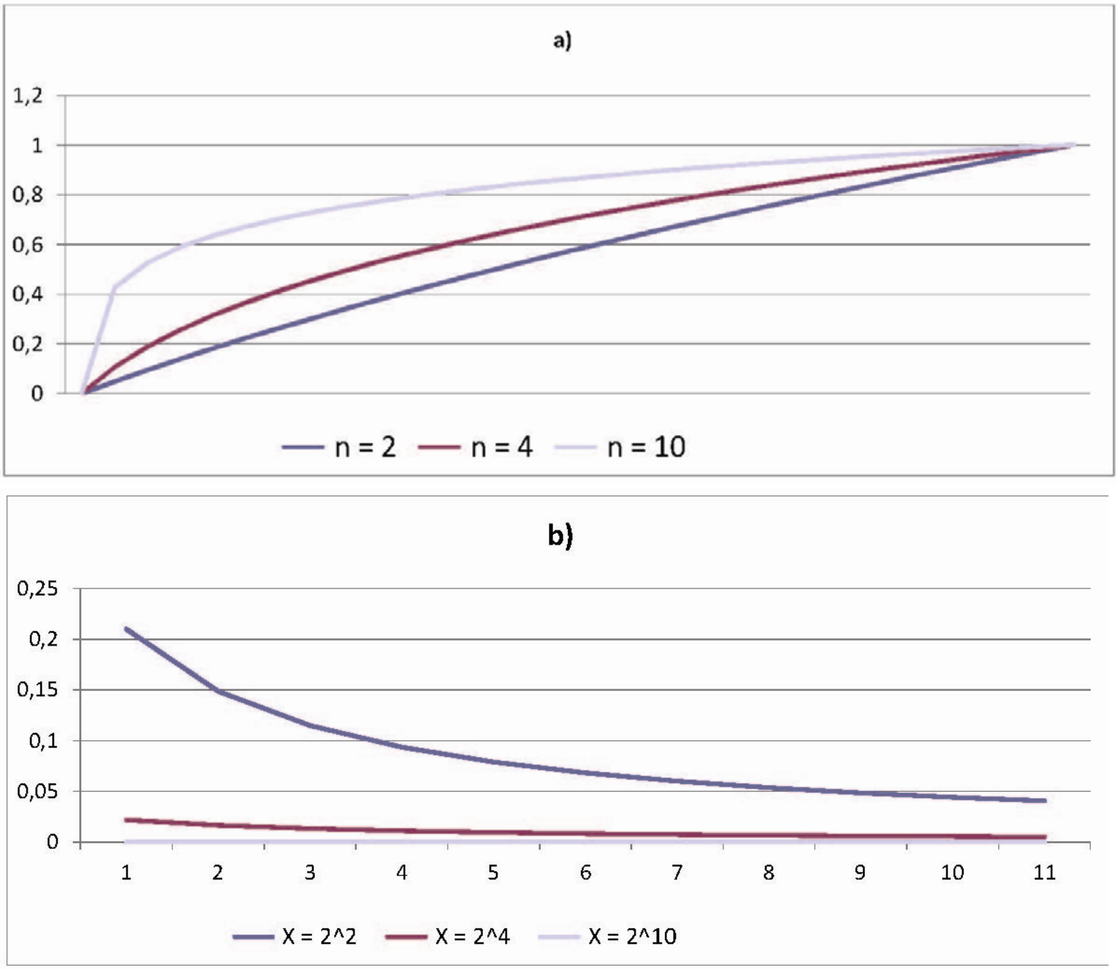

Figure 1 a) Performance of the GSI in relation to the number of variables considered; **b)** Performance of the marginal effects of the GSI when increasing of n and X. n: number of variable (indicators); $X = n\ I_n \prod$

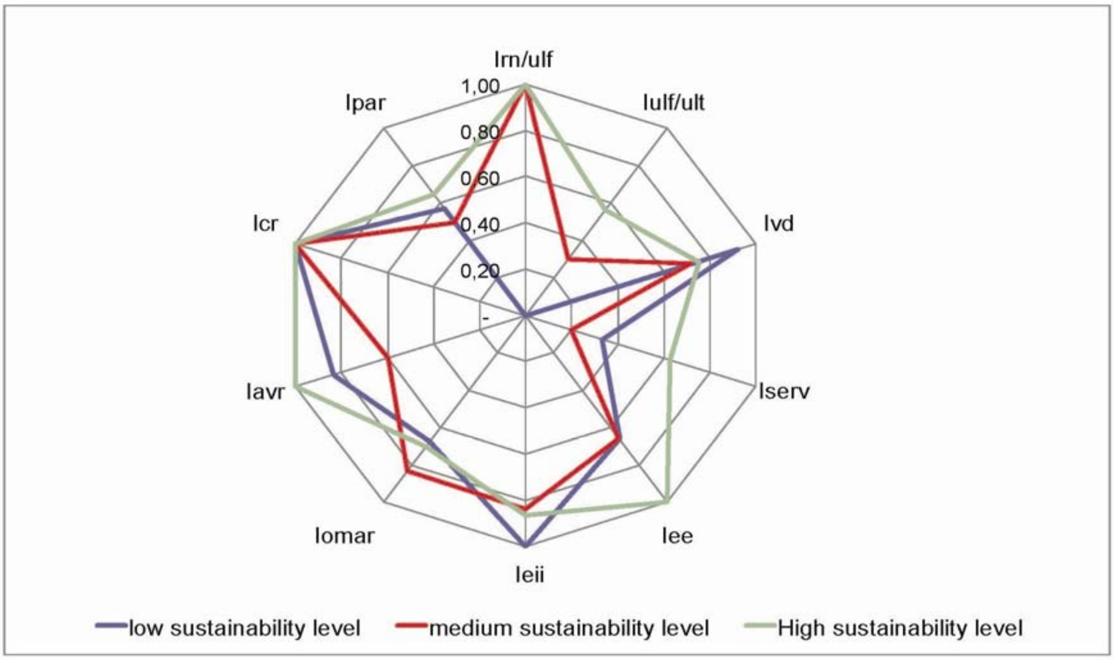

Figure 2 Average values taken from the indexed parameters that make up the GSI distinguished by degree of sustainability

4. Conclusion

The agri-environmental sustainability analysis showed that the organic horticultural farms under study have a good level of sustainability. By analyzing the environmental individual systems it is obvious that these farms have satisfactory crop rotation with very positive effects in the landscape and biodiversity, both planned and associated, as well as land cover, reducing the risk of erosion. The management, however, is not just as good if you look at the soil-water and energy flows. The first was subject to pollution damage to the high presence of nitrates and phosphorus available. Given the low use of organic fertilizers, the availability of these elements are probably a good indication of biological activity by promoting a rapid mineralization of soil nitrogen in the soil. Energy efficiency is negative, showing that the horticultural activity requires more input than there are outputs. Regarding economic efficiency, all farms show positive levels of sustainability. An essential component of economic success lies therefore more in management skills and relational aspects of the company than in technical and structural optimization of production management and the ability to "create the market", using different forms of short chain, allows to incorporate the wealth generated from the production process and make the company competitive.

5. Bibliography

Bell S. and Morse S. (1999) Sustainability indicators: measuring the immeasurable? Earthscan, London

Biondi P., Panaro V. e Pellizzi. G., (1989). Richieste di energia nel sistema agricolo italiano. PFE, Roma, 389 pp.

Castoldi N. and Bechini L. (2010). Integrated sustainability assessment of cropping systems with agro-ecological and economic indicators in northern Italy. Europ. J. Agronomy 32 (2010) 59–72

Codex Alimentarius (2004). Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (GL 32 – 1999, Rev. 1 – 2001). Internet http://www.codexalimentarius.net/web/standard list.do?lang=en. Accessed on 24/11/2011.

Dalgaard, T., Halberg, N., Porter, J.R., 2001. A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. Agric. Ecosyst. Environ. 87, 51–65.

Koga, N., 2008. An energy balance under a conventional crop rotation system in norther Japan: perspectives on fuel ethanol production from sugar beet. Agric. Ecosyst. Environ. 125, 101-110.

Eckert, H., Breitschuh, G., Sauerbeck, D.R., (2000). Criteria and standards for sustainable agriculture. J. Plant Nutr. Soil Sci. 163, 337–351.

FAO (1999) Organic Agriculture. Food and Agriculture organization of the United Nations, Rome. http://www.fao.org/unfao/bodies/COAG/COAG15/X0075E.htm Accessed 8/08/2011

ISTAT (2011). 6° Censimento Generale dell’agricoltura. Internet http://censimentoagricoltura.istat.it/index.php?id=73 Accessed on 20/03/2012

Migliorini, P., Vazzana, C., (2007). Biodiversity indicators for sustainability evaluation of conventional and organic agro-ecosystems. Italian Journal of Agronomy 2, 105-110.

Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., Giovannini, E. (2008). Handbook on constructing composite indicators: methodology and user guide. OECD Statistics Working Paper 2005/3. Available at: http://compositeindicators.jrc.ec.europa.eu/Handbook.htm.

Nicholls C. I., Altieri M.A, Dezanet A., Lana M., Feistrauer D., Ouriques M. (2004) A rapid, framer-friendly agroecological method to estimate soil quality and crop health in vineyars systems. Biodynamics n. 250 p. 33-39

OECD (1999). Environmental indicators for agriculture; concepts and framework, vol. 1. OECD Proceedings. OECD Publication Service, Paris, France.

OECD (2008). Handbook on constructing composite indicators. Methodology and User Guide. OECD Proceedings. OECD Publication Service, Paris, France.

Pacini C., Lazzerini G., Migliorini P. e Vazzana C. (2009). An indicator-based framework to evaluate sustainability of farming systems: review of applications in Tuscany. Italian Journal of Agronomy, vol. 4:1, p. 23-40, ISSN: 1125-4718

Richter, E. D. (2002). Acute human pesticide poisonings. In: Encyclopedia of Pest Management. pp. 3–6. Pimentel, D. Ed., Taylor & Francis, Boca Raton, Fl, USA.

Shannon C.E., Weaver W. 1963. The Mathematical Thoery of Comunication. University of Illinois Press, Urbana, 117.

SINAB (2011): BIO IN CIFRE 2010: il rapporto completo, http://www.sinab.it/share/img_lib_files/1627_bio-in-cifre-2010_con-grafica-x-stampa.pdf, (accesso del 18/01/12).

USDA, 2004. USDA National Nutrient Database for Standard Reference. United States Department of Agriculture. Accessd on: http://www.nal.usda.gov/fnic/foodcomp/search.

Vazzana C., Raso E., Pieri S. (1997) Una nuova metodologia europea per la progettazione e gestione di agroecosistemi integrati ed ecologici: applicazione in un’area agricola toscana, Italian Journal of Agronomy, 31(2) pag.423-440

Vereijken, P., (1997). A methodical way of prototyping integrated and ecological arable farming systems (I/EAFS) in interaction with pilot farms. European Journal of Agronomy. 7, 235-250.

Willer H. and Lukas (2011)Willer, H. and Kilcher, L. (Eds.) (2011) The World of Organic Agriculture - Statistics and Emerging Trends 2011. IFOAM, Bonn, and FiBL, Frick