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RISE, a Tool for Holistic Sustainability Assessment at the Farm Level

Fritz Häni [a], Francesco Braga [b], Andreas Stämpfli [a], Thomas Keller [a], Matthew Fischer [b], and Hans Porsche [b]

[a] *Swiss College of Agriculture (SCA), University of Applied Sciences Bern, CH-3052 Zollikofen.*
[b]*University of Guelph, Guelph N1G 2W1 Ontario Canada.*

Abstract

Sustainability must be adopted as a key principle in global markets. Numerous studies have been conducted to evaluate the degree of sustainability on a national and local level. However, only little information for single farm assessment is currently available.

The present paper introduces a tool, the "Response-Inducing Sustainability Evaluation" (RISE), which allows an easy assessment at the farm level. It is system-oriented and offers a holistic approach for advice, education and planning. The model covers ecological, economical and social aspects by defining 12 indicators for Energy, Water, Soil, Biodiversity, Emission Potential, Plant Protection, Waste and Residues, Cash Flow, Farm Income, Investments, Local Economy and Social Situation. For each indicator a "State" (S) and a "Driving force" (D) are determined from direct measures of a number of parameters. The "State" indicates the current condition of the specific indicator, higher values are more desirable, and the "Driving force" is a measure of the estimated pressure the farming system places on the specific indicator; in this case lower values are desirable. D and S are standardized on a 0 to 100 scale; a perfect indicator would be identified by S=100 and D=0, whereas significant challenges would be captured by a combination of a low S and a high D. The degree of sustainability (DS) of each indicator is defined as DS= (S-D), bound by construction to the -100 to +100 range. The overall results are summarized and displayed in a sustainability polygon. In addition to this polygon a strength/weakness profile is determined for 1) the stability of the social, economic and ecological framework,

Corresponding author: Tel: + 1-519-824-4120
Fax: + 1-519-837-9297
Email: fbraga@uoguelph.ca

2) farmer's risk awareness and risk management measures, 3) grey energy in machines, buildings and external inputs, 4) animal health and welfare.
RISE has been tested and used to evaluate very different farms in Brazil, Canada, China and Switzerland. Results are considered relevant with regard to the objective stated. Further testing, adaptation and fine-tuning is under way. A similar model covering the supply chain to the factory gate is also under development.

Keywords: Sustainability assessment, Sustainability at the farm and crop level, Indicators of sustainability, Driving Force - State - Response (DSR) – model

Background and Aims

Market liberalization is often considered the main driver of development, but it is essential to retain sustainable development as the most important leading principle of this process (Stückelberger 1999). What does sustainability really mean? Some understand it as "the simplest and most elegant of concepts (which) simply means the capacity of continuance" (Porritt 2001; cf. also UNEP 1991). However, if continuance is only due to strong protection measures, very negative side effects may result, hence a more appropriate definition is needed. The Brundtland Commission (WCED 1987) stated: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". As argued by Stückelberger (1999) it is important to add two more dimensions: "human dignity" and "non human environment".

The basic definition of sustainable development for the present work therefore reads as follows (Stückelberger 1999, modified) :

Sustainable Development allows a life in dignity for the present without compromising a life in dignity for future generations or to threaten the natural environment and endangering the global ecosystem.

Several authors point out that a production process that simply follows the biological principles of sustainable development is not necessarily meaningful by itself, and that additional considerations, for example specific market and ethical considerations, are necessary to achieve this determination (Boff 2000, Küng 1997, Ulrich 1987).

It is generally accepted, then, that the three key factors of sustainable development are: environmental protection, economic efficiency and solidarity in society. Accordingly, a more precise operational definition of sustainability is necessary to work at the farm level. This work adopts a modified version of the recent definition of sustainable agriculture adopted by the Sustainable Agriculture Initiative (SAI, 2003):

Sustainable Agriculture adopts productive, competitive and efficient production practices, while protecting and improving the natural environment and the global ecosystem, as well as the socio-economic conditions of local communities.

Numerous studies have been conducted to evaluate the degree of sustainability on a national and local level and broadly accepted indicators have also been recommended (e.g. Meadows 1998, OECD 2000, UNO 2001). Only limited information is available for the precise assessment of a single farm. RISE, a model for the **R**esponse-**I**nducing **S**ustainability **E**valuation at the farm level, was developed to fill this gap and to provide a simple and robust tool for the holistic assessment of the sustainability of an individual farm and to provide "Response Inducing" practical and easy to understand indications on the changes necessary to improve the sustainability of the farming operations. This work is based on the mentioned publications of OECD and UNO (OECD, 2000; UNO 2001); on earlier research work on farming systems (Häni 1990, 1993; Häni et al. 1998); on life cycle assessments (FAL 2002); and on the development of indicators at the farm level (Briquel et al. 2001, Girardin et al. 1994 and 1999).

The goals set for the RISE model are to provide (Häni et al. 2002 and 2003):
A holistic approach, using relevant indicators for individual aspects as well as for the whole farming system. The choice and the determination of relevant parameters follow the principles of ISO-14040 norms for life cycle assessment.

- An easy instrument for the comparative evaluation of the sustainability degree of different farms and a planning tool for the improvement of the sustainability of individual farms.
- An instrument applicable for different farm types and conditions as well as throughout different countries.
- Indicators, data procurement and interpretation of the results that are verifiable and understandable for farmers and the public.
- A clear visualization of the effect of individual measures on the entire farm system.

Clear indications to the entrepreneur who can use them to understand and appreciate both the strengths and the weaknesses of the current farm system as well as the necessary changes (hence a response-inducing approach) that would result in improved sustainability.

Principles and Method

RISE is based on twelve indicators of economic, ecological and social situation: Energy consumption, Water consumption, Soil stewardship, Biodiversity, Emission potential, Plant protection, Production of wastes and residues, Cash flow, Farm income, Investments, Contribution to local economy, Social situation of farm family and farm employees. The analysis is defined spatially by the farm area and temporally by a one-year period. A key characteristic of the model is the evaluation of both the "State" (S) and "Driving Force" (D) for each indicator. This allows a combination of a systems and an analytical approach: the calculated "Degree of Sustainability" (DS = S–D) takes into account both the actual situation of (S) and the pressure (D) on the specific indicator; a high D is likely to result in a low S over time. D allows to take into account the long-term tendencies and risks which are crucial for an operational sustainability concept. Whereas S can serve as an analytical data base for the actual situation, DS additionally includes systemic trends (cf. Vester 1983). The instrument allows the identification of strong and weak aspects of the farm and can thus induce managerial decisions leading at improving sustainability, hence the "decision-oriented, response-inducing approach".

To determine the value of D and S a trained analysts must complete an in-depth farm assessment. This requires a site inspection to collect all relevant biological parameters; an evaluation of the economic condition of the firm and of its relevant market of reference to collect a number of firm-specific economic parameters; a collection of secondary data mostly related to a number of social parameters and to macroeconomic data. Proprietary software is used to calculate the standardized values of DS for the 12 sustainability indicators. Under quasi-ideal situations, the entire process requires between 1.5 and 2 full time equivalent days, including a discussion of the results and their managerial implications with the farm entrepreneur. Scheduling issues may significantly increase these figures, in particular as long as the indicator is relatively new and not widely known.

The logical underpinning of RISE's approach is outlined in Figure 1.

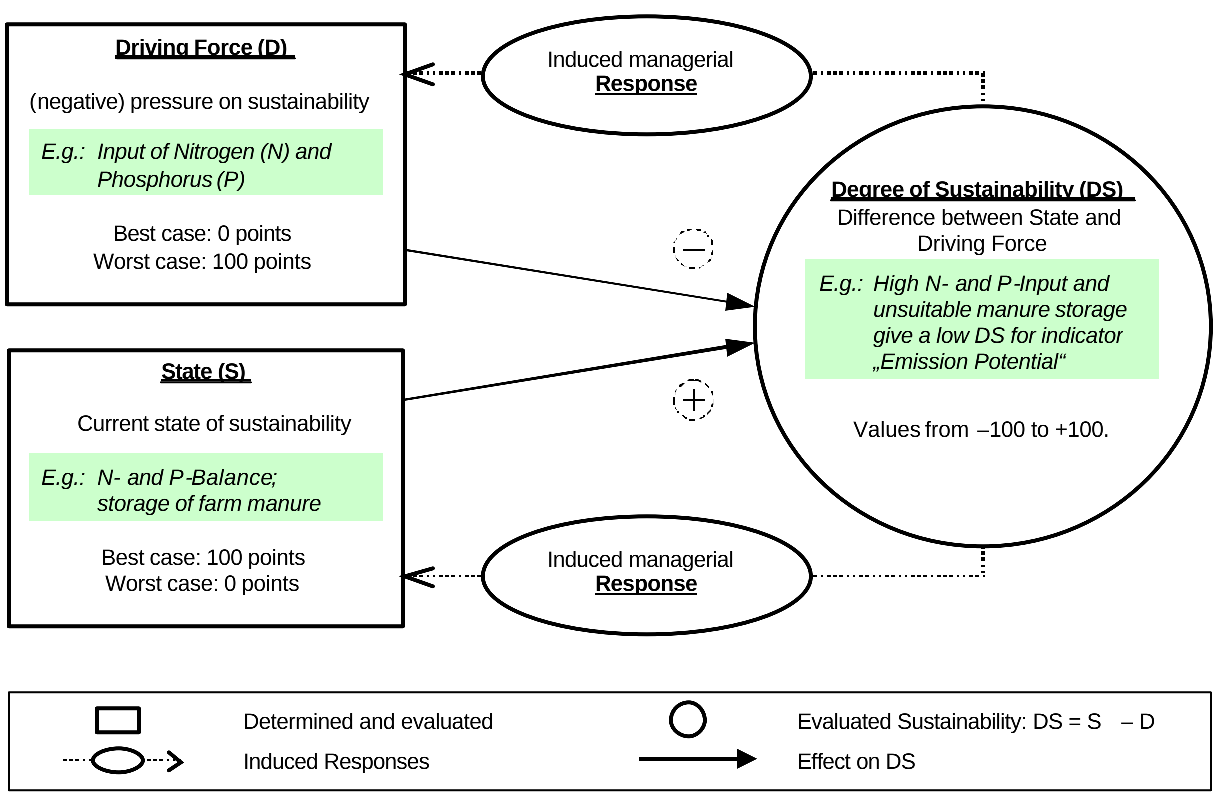


Figure 1: Schematic approach of the response-inducing sustainability evaluation (RISE).

Individual indicators are considered sustainable if DS is above +10, the whole farm is considered sustainable if no indicator has a DS below –10. A sustainability polygon is used to visualise the value of S, D and DS for the 12 indicators and to facilitate their interpretation. Examples are presented in Figures 2 to 7. In an ideal situation the polygon would not show extreme values for individual indicators but rather an homogeneous band of positive values for DS. The interpretation of the results will identify weak aspects of the farm and will thus induce steps to improve the situation.

In addition to the sustainability polygon the following 4 dimensions are assessed on a simplified scale: 1) stability of the social, economic and ecological framework, 2) farmer's risk awareness, attitudes and management, 3) grey energy (machines, buildings, external inputs), 4) animal health and welfare. For each dimension the assessment is an "A" in case of a strong assessment of the farm, "B" in case of an acceptable assessment, and "C" in case of a weak assessment. A "C" rating is considered not favourable for sustainable development. Table 1 provides examples of parameters considered in the calculations.

The table presents the most recent definition of the indicators; figures 2 to 6 reflect an earlier version.

Results and Discussion

Figure 2 illustrates the results of the sustainability assessment for a typical mixed Swiss farm producing livestock and cash crops. The polygon on the left of the figure documents the result of the evaluation of the actual situation, the polygon on the right documents the change in sustainability resulting from corrective actions that could be initiated following the analysis of the polygon results.[1] The results can be considered as rather typical for many farms working along the lines of the Swiss agricultural policy with direct payments for ecologically beneficial farming systems. The most serious handicap is the unsustainably low level of farm income. Energy consumption and wastes are other weak aspects. The farm could clearly improve its situation by optimising the cattle housing system and investing into renewable energy systems (biogas, canola oil driven tractor).

[1] Changes betveen Current and Optimized situation are firm-specific and are driven by the particular driver of the DS for a specific factor. The polygon is the graphical summary representation of RISE, which is completed by a managerial discussion of the detailed results, not presented here because of space constraints.

Table 1: Indicators of sustainability.

Indicator	Parameter	Basis of data	Units of reference
Energy	D(1)	Energy usage	ha FL(3)
		Environmental impact (global warming, air pollution etc.)	Farm
	S(2)	Energy consumption per Workforce (FTE(6))	Farm
		Degree of self sufficiency for energy consumption	Farm
Water	D	Water consumption	ha FL
	S	Stability of water source	Farm
Soil	D	Soil contamination through fertilizers and pesticides	ha FL
		Effect on the soil by farm machinery	ha FL
	S	State of the soil (a): Nutrients, carbon, pH, moisture, salinity	ha FL
		State of the soil (b): Erosion	ha FL
Bio-diversity	D	Zones of ecological compensation (ZEC's): Surface of ZEC's; compliance to the law	ha FL
		Size of plots (only those without high biodiversity)	ha FL
	S	Surface with high biodiversity	ha FL
Emission Potential	D	Input of nitrogen (N) and phosphorus (P)	ha FL
	S	N & P-balance (supply and demand)	Farm
		Storage of farm manure	Farm
Plant Protection	D	Crop rotation	CP(4)
		Quantity of active ingredients	ha FL
		Risk potential of pesticides used	ha FL
	S	Plant protection system	Farm
		Education, equipment control, observance of waiting periods, existence of buffer zones	Farm
Wastes and Residues	D	Wastes produced	Farm
	S	On-farm wastes disposal	Farm
		Off-farm wastes disposal and / or recycling	Farm
Cash Flow	D	Depreciations, amortization and loss as % of capital	Farm
	S	Return on assets	Farm
Farm Income	D	Number of FTE(6) multiplied by MRI(5), as % of sales	Farm
	S	Farm income, as % of previous measure (absolute value)	Farm
Invest-ments	D	Condition of buildings, equipment, permanent crops	Farm
		Equity ratio	Farm
	S	Maintenance and investments as % of total capital	Farm
Local Economy	D	Sales in relation to a regional benchmark	ha FL
	S	Relative size and compensation level of local workforce	Farm
		Lowest salary paid as % of MRI	Farm
Social Situation	D	Relation between average FTE compensation on the farm and MRI	Farm
		Relation between lowest FTE compensation and farm income per FTE	Farm
	S	Assessment of the social situation of family workers and employees	Farm

D = driving force; (2)S = state; (3)FL = farmland; (4)CP = crop period; (5)MRI = minimum regional income; (6)FTE = full time equivalent.

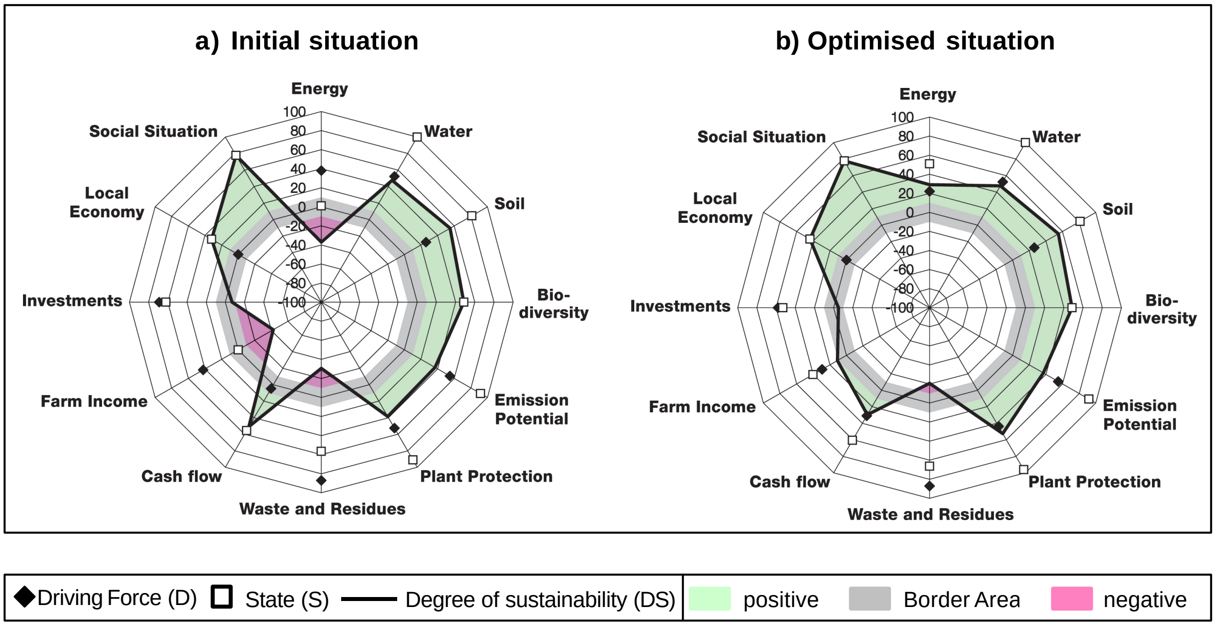


Figure 2: Swiss mixed livestock and crop farm: 19 ha; 1.5 Large animal units/ha; 2.5 Full Time Employees (FTE).

Figures 3 – 5 show the results of farms from the district of Shuangcheng, near Harbin in Northern China, Province of Heilongjiang. Figure 3 shows a typical example of a milk supplier to the Nestlé factory in Shuangcheng: The actual economic and social situation is good, but there is a very serious problem concerning the emission potential. This problem is due to a surplus of organic manure (high animal density) as well as mineral fertilizer and to a missing or unsuitable storage of manure. Scenario b) was calculated assuming a 30% increase in the price of soybeans, used as animal feed, and a 10% decrease in the price of milk. The result shows that the farm income is highly dependable on these two external factors and the economic situation can be considered as rather fragile.

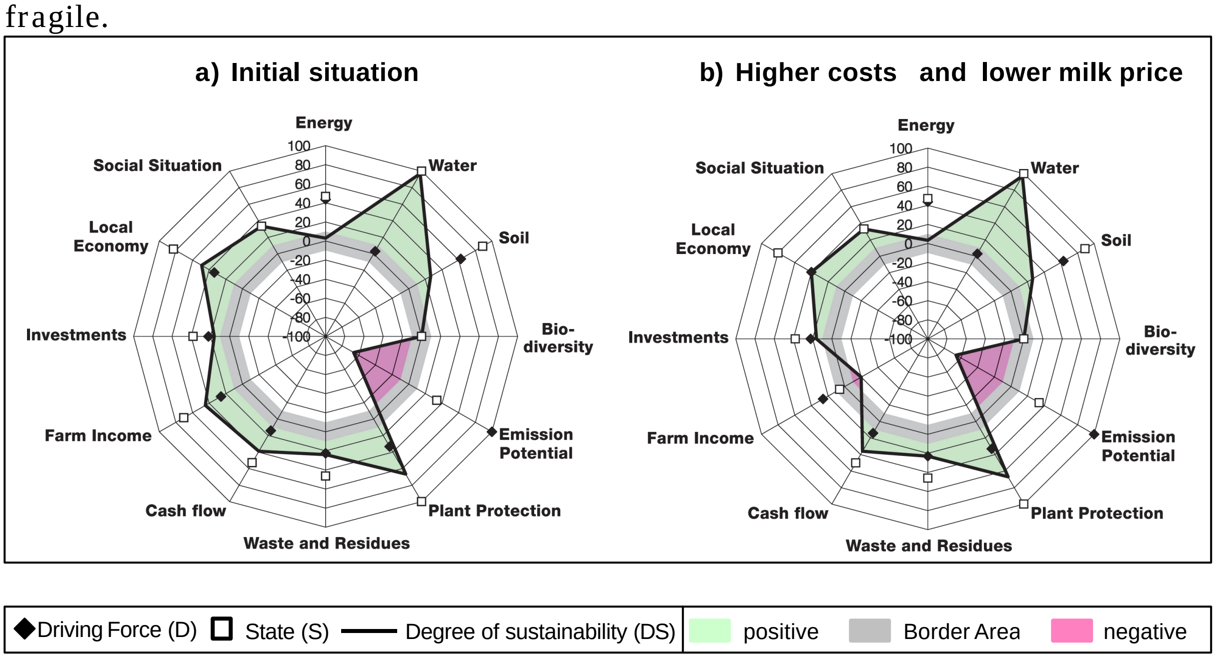


Figure 3: Dairy cattle farm in China: 0.7 ha; 4.3 Large animal units/ha; 2.0 FTE

Figure 4 shows another typical example of a Nestlé milk supplier. This farm with a livestock density of 25 Large animal units (LU)/ ha (most of the fodder comes from outside the farm) is economically sound but has a very high emission potential. Scenario b) shows that the situation can be improved considerably by recycling the manure as fertiliser. Investments are required in the areas of manure storage, transport and spreading and 85% of the manure has to be exported to local cash cropping farms. It is likely that in farms with less favourable economic conditions, but the same necessity to reduce the emission potential, similar investments would lead to a negative result for the farm income.

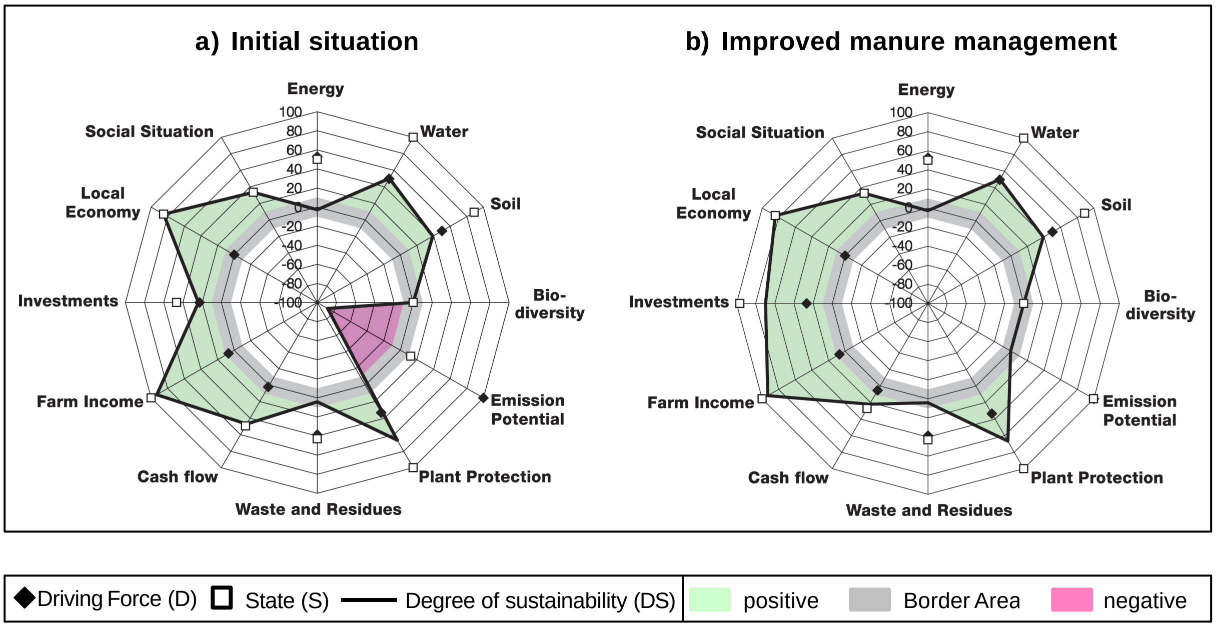


Figure 4: Dairy cattle farm in China: 1.4 ha; 25 Large animal units/ha; 6 FTE

Despite its relatively large land base, the cropping farm in Figure 5.a achieves a less favourable economic result than the Chinese dairy farms, but it has also a lower emission potential. Farm in 5.b is a very small farm, even by regional standards. It grows only maize and farm income is very low. It is striking that this small farm has also a very high emission potential, the result of excessive use of fertilizer.

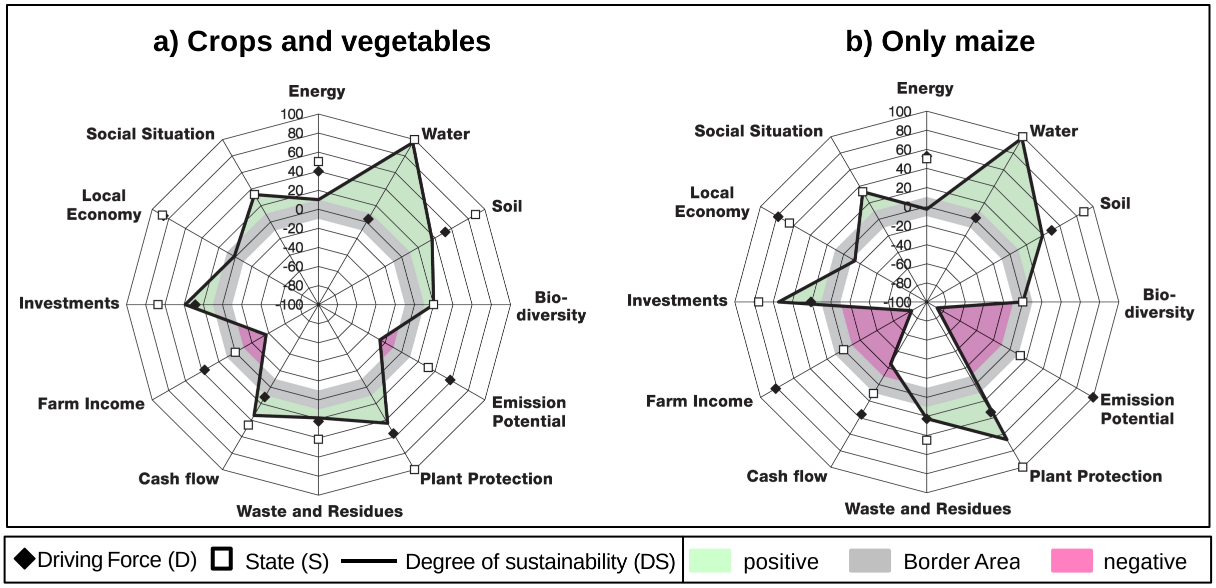


Figure 5: China; a): Mixed crop (maize flax cabbage spinach) farm, 5.4 ha; 5 FTE b): maize operation only 0.6 ha, 1.8 FTE

The farm in Figure 6 was the world's second largest cocoa producer, but ran into serious economic problems due to price decrease and a disastrous cocoa disease (*Crinipellis perniciosa*). Compared to the exclusive production of cocoa (Figure 6a), the additional diversification in to the production of palm hearts and coffee improves the economic situation considerably (Figure 6b). This example illustrates how the RISE-model can also be used to complete sensitivity analysis for example considering different crops or different market conditions.

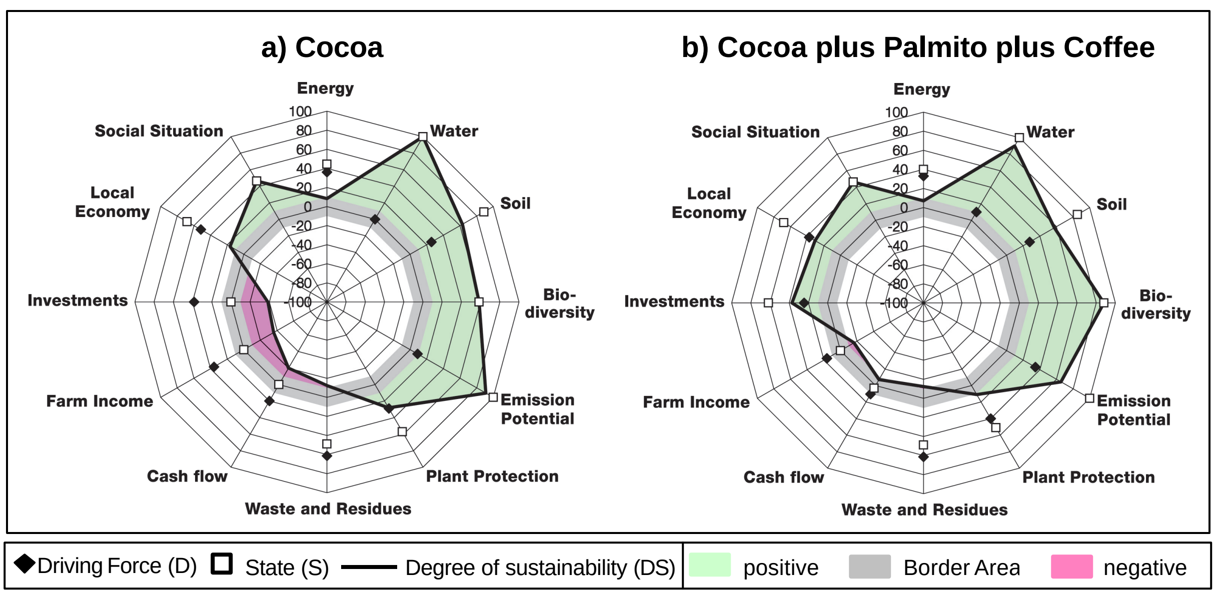


Figure 6: Brazil, large cocoa, palmito and coffe producer: 1940 ha cocoa, 359 ha palmito, 122 ha coffe, 682 FTE.

Testing RISE in North America

Farming operations in Switzerland, China, Brazil, do differ significantly from specialized North American farms in size and resource endowment, including level of mechanization, labour and capital intensity. Therefore, whereas some fine-tuning may be necessary, RISE may become an interesting research tool to document sustainability implications of a number of scenarios. The North American testing and fine-tuning of RISE is beginning on a number of farms in Ontario, Canada.

Issues that will need careful evaluation to validate RISE's standardization process, include the following: off-farm industry practices, such as specific accounting or lending practices; government regulations, such as pollution controls, farm nutrient management legislation, food safety programs such as HACCP (Hazard Analysis Critical Control Points), international trade agreements, immigration legislation limiting access to seasonal labour, availability of social services and infrastructures in rural areas; tax regulation, for example the treatment of financial figures based on cash or accrual accounting; market regulation, for example supply management in dairy and other agricultural commodities; farm structure, intensive operations with limited land base; controlled environment operations, such as green-houses; differences between organic and conventional farms.

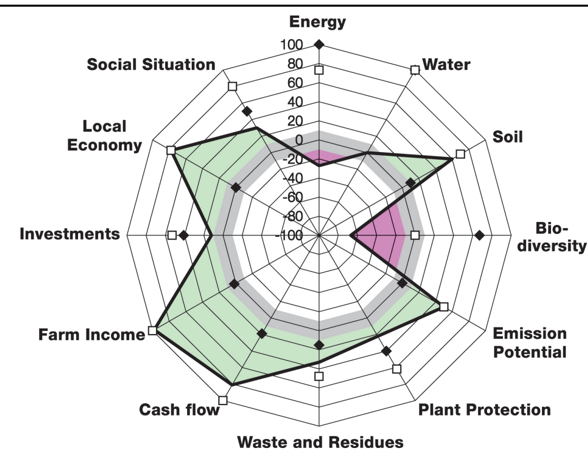
Of specific interest are also the possible differences between smaller diversified farms, often considered hobby farms, and large specialized operations. Of further relevance is the consideration of extremely specialized operations, relying on third party off-farm suppliers to perform operations normally completed on-farm in a more traditional framework. These highly specialized operations can likely be properly assessed only in the broader context of a supply chain that considers these custom work suppliers and corporate partners. Additional questions may be raised relative to availability of seasonal work force, specialized and not, often originating from other regions of the country or even other countries.

Figure 7 illustrates the assessment result of a farm with some of the challenges just mentioned. The farm considered is a large chicken operation, part of an integrated corporate family farm (a family-owned holding company owning a number of incorporated and specialized production units). The specific unit considered is set on approximately 7.5 ha of land, approximately 20% of which is occupied by buildings. Feed is produced off-farm by a separate unit of the same company, chicks are purchased from specialized producers, manure management is contracted out to a custom operator who transports it off-farm to an industrial user. The operation is capital intensive, and it is run by only 1.25 FTE labour units, other than specialized third party suppliers and custom workers.

The Soil and the Plant protection indicators values in Figure 7 include qualitative estimates of some parameters which could not be completely quantified during the on-farm inspection. This is not per se a weakness of RISE, it simply underlines the profound differences between this specialized chicken producer (an industrial agricultural operation with no agricultural land other than that occupied by the actual barns and access roads) and a diversified traditional farm.

The farm shows a poor Bio-diversity and Energy indicator. These are not surprising results, considering the high energy consumption of the operation, and the highly specialized nature of the operation, with almost no land. Good income, cash flow and local economy reflect the nature of the supply managed industry and the fact that the operation is located in a wealthy area of rural Ontario, with significant opportunities for off-farm and non-farm income. The operation does not need much new investment as all equipment and buildings are relatively new, and the company is relying on custom work for several operations and is well financed by the holding company. The Water indicator is set to 0 as the company is well endowed with own water wells with a stable water table (hence a renewable resource), but it is also penalized because of an overall high water consumption.

Figure 7: Large Ontario chicken operation. 1.25 FTE, 7.5 ha, 700,000 birds/yr.



Conclusions and Outlook

Rise has been successfully tested on very different farm types under variable conditions in Brazil, China and Switzerland. It achieves the stated objectives and it can be a valuable instrument for the easy assessment of the sustainability of farms. This provides a solid foundation for further validation and expansion of this very flexible tool. At the present time, work is under way in a number of areas, to complete additional testing across various farm types, in countries with very different agricultural systems; to develop a protocol to document and discuss managerial implications for agribusiness and a sensitivity analysis and stress testing protocol; to develop a regional aggregation protocol; to develop a similar tool for the sustainability assessment of the entire supply chain.

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