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SUSTAINABILITY ANALYSIS OF AGRICULTURAL SYSTEMS

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Abstract

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The main aim of this research is to propose an evaluation method as a tool for measurement of sustainable development in agriculture. The research has three parts: 1) indication, 2) evaluation and 3) application. Three aggregate and a group of partial indicators were selected for ecological, economic and social dimension of agricultural system. As the aggregate indicators were proposed: Material and Energy Costs, Operating Income and Personal Costs. Two evaluation methods for calculation of relative sustainability for group of farms were proposed: The Method of Comparison of Indicator Values and The Method of Comparison of Weighted Interval Sustainability. Each method was tested in static and dynamic variant with using of financial data of 30 farms in the CR. Proposed Index of Weighted Interval Sustainability is applicable in farm management and in agricultural policy with aim to redistribute subsidies.

sustainability, agriculture, system, farm, indicator, evaluation

The problem of sustainable development is discussed parallelly in two branches: in science, that is concentrated particularly on analysis of unsustainable state; and in policy that deals with regulations and strategies toward the sustainability. In 1969 U Thant Secretary General of United Nations appealed to world public for immediate actions to improve environment, and to cope with population growth. Problem of ecological crisis were pointed out at United Nations Conference in Stockholm in 1972. Meadows et al., [1972] used a simulation model for analysis of a need of resources and population growth. Meadows came in "Limits to Growth" to conclusion, that it is very important to stop economic growth, because there is danger induced by depletion of resources and environmental contamination.

Conception of sustainable development was first published in "Our Common Future" report [WCED, 1987]. The conception of sustainable development was generally accepted in "Agenda 21" at the United Nations Conference in Rio de Janeiro [UNCED, 1992]. The Agenda 21, plan of action for implementing sustainable development states: "Major adjustments are needed in agricultural, environmental and macroeconomic policy." The major objective of sustainable agriculture and rural development is to increase food production in sustainable way and enhance food security. This will involve education initiatives, utilization of economic incentives and the development of appropriate and new technologies, thus ensuring stable supplies of nutritionally adequate food, access to those supplies by vulnerable groups; employment and income generation to alleviate poverty; and natural resource management and environmental protection" [UNCED, 1992].

The research of sustainability gives the main attention to indicators, which are tools for measurement of sustainability. Freyenberg, Janke and Norman [1997] cite more than 80 pieces of literature relating to indicators of sustainability in agriculture and whole-farm planning. A short list of chosen authors of methods and indicators shows chapter 4. Review of literature relating to indicators.

This analysis of sustainability studies system stability and viability in ecological, economic and social dimension and it therefore synthesises natural science and humanities. The indication and evaluation of agriculture is proposed at farm level, because farm is subject, whose activity shall be managed toward sustainability. The research is described in chronological order: 1) determination of object and users needs, 2) setting criteria for analysis, 3) proposal of indication methods, 4) review of literature relating to indicators, 5) proposal of aggregate and partial indicators, 6) proposal of evaluation methods, 7) test of proposed methods and indicators, 8) proposal of application, 9) results and discussion.

OBJECT AND USERS

The concept of sustainable development has a hypothetical character. The fundamental question of sustainable development is: Where are the limits? What is perspective and sustainable? Concept of sustainable development is not time limited and it is generally referred to the future. The definition from Our Common Future report is very often used: "Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future". [WCED, 1987] A statement about sustainability of some type of development will remain a hypothetical one until the end of predicted time period when it will be verifiable.

The users of basic research are scientists and students who use knowledge of sustainability for their next research. Orientation and parameters of applied research correspond with the need to resolve actual problem. Potential users are in science, political, civil and farm sphere. The holistic approach is not acceptable for specialised science, but it is essential for application. Environmentally educated citizens can use research outputs to change their behaviour. Environment and society are influenced by customers decisions about what kind of and what amount of energy and materials to use and how much waste to produce. Politicians make normative or economic instruments for rural development, employment and environmental protection. Politicians need easy instruments for distribution of subsidies. Farmers need inexpensive indicators limited at number for change of management and optimisations of costs and benefits. The final state must be compromising decision of different groups of users.

CRITERIA FOR ANALYSIS

If we are to manage our way to sustainability, we must make the change from valuing what we measure to measuring what we value [Chambers et al., 2001]. The main values for sustainability were selected: viability of ecological, economic and social dimension. According Chambers good indicator must be: resonant – clear and easy to interpret and within the sphere of understanding and relevance of the user; valid – the data from which the indicator is drawn need to be as comprehensive and credible as possible and the method used to develop the indicator must be as transparent as possible; motivational – reflecting issues that are within the sphere of influence of the user, so "provoking and inspiring" change.

The criteria for indicators were set up in this research: common language base for users groups, same units for dimensions, aggregation, limited number of indicators, data control, unexpensiveness, understandable outputs. System analysis needs aggregate indicators, which serve complex information about group of characteristics, and makes possible complex monitoring. Number of indicators was limited at one indicator for dimension. The indication was proposed in monetary units, because agriculture policy effectively operates with monetary instruments. Same units reduced distance between analysis and policy decision. Partial research, for example biodiversity analysis does not make the sustainable development possible. There were proposed one aggregate indicator for each dimension at same level of aggregation. Recycling of data for financial evidence and tax purposes corresponds to criteria of inexpensive data collection and processing. Policy application needs controlled and guaranteed data. Own control and grantee system for sustainable development may be redundant. Common financial terminology of accounting was used because it is possible to explain research outputs to a scientist, politician and farmer. The usage of common concepts, data recycling and limited number of indicators enable universal and understandable outputs.

METHODS OF INDICATION

Sustainability is a system ability to multiply and to connect function and thereby increase probability of system survival. Agriculture system can be modelled as a three level pyramid. The model shows chronological development of dimensions and their dependence. Ecological dimension as a primary source of system is at the basic level. The median level is represented by economic dimension, which depends on ecological dimension. The top level is represented by social dimension that depends on both environmental and financial resources. Stability of system increases with number of direct and indirect links and with number of types of elements.

Horizontal analysis deals with function of one dimension. For example: it analyses in ecological dimension: biodiversity, production of biomass, soil erosion control, ecological stability, etc. The horizontal analysis of agriculture management can be used for partial evaluation, but it does not provide information about a whole system.

Vertical analysis studies main functions of an entire system. Examples of function in economic dimension are: profitability, regional self-sufficiency, reliance on government programs, etc.. Examples of function of social dimension are: creation of jobs, direct links between farmers and producers, agro-tourism, etc.. Vertical analysis has complex character and it describes system as a whole.

REVIEW OF LITERATURE RELATING TO INDICATORS

This review is restricted to some representative authors of methods and indicators applicable in research of agricultural sustainability. Many indicators are very specialised and only a few indicators allow vertical analysis across the system. The indicators were divided into six groups by their object of indication.

First group of indicators monitor quality of environment: quality of soil [Doran, 1994], soil microbial process [Viser and Parkinson, 1992], water regime [Rao, 1993], biodiversity and nutrient cycling mechanism [Edwards et al., 1993].

The second group of indicators studies material and energy consumption. Baccini and Brunner [1991] developed method for monitoring of material flows into industrial region. Schmidt-Bleek [1994] developed method material intensity per unit of service with combines life cycle analysis and material accounting to determine the overall mass transformed for a given process. Vitousek et al. [1986] analysed total production of biomass and its utilisation. Pervanchon et al. [2002] developed energy indicator based on analysis of four type of energy: two for indirect energy (pesticides and fertilisers) and two for direct energy (machinery and irrigation systems). Edwards et al. [1993] presented farm model with through-flow where biophysical inputs (energy, chemicals, water) lead to outputs (food, fibre, energy).

The third group of indicators analyses human need of biosphere. Ecological Footprint developed by Wackernagel and Ress [1996] transforms impacts of subjects and activities on resources, waste production and environmental function. Material and energy inputs and outputs are transformed into six categories: fossil energy consumed expressed in the land area, degraded land or built up environment, gardens, crop land, pastures and prime forest area. Jílek [2001] applied ecological footprint to a farm level.

The fourth group of indicators deals with production procedure. Christen [2001] studies productivity of different types of land use: rotation of crops, frequency of cultivation, nutrient and energy balance and usage of plant protection. Haller and Keoleian [2000] used the method of Life-Cycle Assessment of product to analyse inputs and outputs during packaging, distribution and consumption of farm products. Approach of Environmental Impact Assessment evaluates impact of construction and activities on environment and population.

The fifth group of indicators is focused on social-economic sphere. Dobbs and Cole [1992] used the following indicators: changes in income of agricultural households; backwards linkages to input supply firms; forward linkages to transportation, processing and marketing firms; and changes in consumers expenditures. Bingham and Savory [1990] used the method of holistic management, which contains financial, land and grazing planning and monitoring. Pomeroy [1997] suggested as indicators: health and safety, command over and availability of key goods and services, participation in social and public affairs. Hanuš and Ulčák [2000] evaluated links between farmer and consumer by: directness, distance, joint decision, joint investment and sharing of risk.

The sixth group of indicators analysed all dimension of system. Levins [1996] proposed four indicators that can be used to evaluate the sustainability of farming operations: reliance on government programs; use of equipment, chemicals, and non-renewable energy; creation of jobs; and balance between feed use and feed production. The OECD [2000] published long list of environmental indicators for agriculture divided into four groups: agriculture in the broader economic, social and environmental context; farm management and the environment; use of farm inputs and natural resources; environmental impact of agriculture.

PROPOSAL OF INDICATORS

According to selected criteria and sustainable trends three aggregate and group of partial indicators is proposed. Proposed indicators are in monetary units CZK.ha^{-1}.yr^{-1}. (Exchange rate is about 1 EUR : 30 CZK) Because proposed analysis recycles financial data, this study does not contain methods of data collection. Data of proposed aggregate indicators are in the "Profit and Lost account" (in CR in line 9, 12 and 29 in units CZK.yr^{-1}).

Aggregate indicator of ecological dimension - Material and Energy Costs (MEC) represents amount of resources, which farms spend on purchase of machines, equipment, fuel, buildings, chemicals and so on. Reduction of MEC means sustainable trend in ecological dimension. Eleven partial indicators are selected for detailed analysis: agro-technical and agrochemical services, fertilisers, plant protection agents, seeds and planting stock, feeding and bedding, building material and component, repairs and maintenance, water, fuels and electricity.

Aggregate indicator of economic dimension - Operating Income (OI) studies financial flows into and out of system and indicates its stability. Increased of profit means sustainable trend in economic dimension. The following partial indicators are chosen: revenues from own products and services, revenues from plant products, revenues from animal products and subsidy.

Aggregate indicator of social dimension Personal Costs (PC) indicates how much a farm paid for labour, etc. rate how much a farm supports employment and stability of rural area and the state. Increasing personal costs means sustainable trend in social dimension. Two partial indicators are selected: wages and salaries and social security expenses.

PROPOSAL OF EVALUATION METHODS

A retrospective analysis of unsustainable limits is much easier then to find what will be sustainable. Calculation of absolute value of sustainability is impossible because so many factors impacts on agricultural system. Relative sustainability is proposed to measure in a group of farms.

1) The Method of Comparison of Indicator Values

The method is appropriate for the comparison of relative sustainability in dimension of farms with aggregate and partial indicators. The method allows comparing each indicated value in relation to the average value of indicator. The method makes possible analysis of changes in dimension in time period. But the method cannot give information about sustainability of system.

2) The Method of Comparison of Weighted Interval Sustainability

The method is appropriate for comparison of aggregate indicators in group of farms. Small number of aggregate indicators makes evaluation clear and it does not change results too much. The method weighs dimensions by their functions and importance in system. There is assigned value 3 to ecological, 2 to economic and 1 to social dimension.

The method analyses intervals of sustainability in dimension according to minimal and maximal indicator value and according to probability of theirs occurrence around these limits. Interval of ecological dimension is determined from 0 to maximal value of MEC in the farm group ($CZK.ha^{-1}.yr^{-1}$). The interval of economic dimension is defined from maximal absolute value of OI to minus maximal values of OI in farm group ($CZK.ha^{-1}.yr^{-1}$). The interval of sustainability in social dimension was defined from 0 to maximal value of PC in farm group ($CZK.ha^{-1}.yr^{-1}$). There are assigned sustainability 0% and 100% to interval limits according sustainable trend. Interval sustainability of dimension is counted according its position in interval. The method calculates interval sustainability of farms as an index, with values from 0% to 100%. Interval sustainability of ecological dimensions is counted according to equation no. 1:

$$ISekol = 1 - (MEC / MECmax), \quad (1)$$

where: ISekol is interval sustainability of ecological dimension (%), MEC are material and energy costs ($CZK.ha^{-1}.yr^{-1}$), MECmax are maximal material and energy costs in farm group ($CZK.ha^{-1}.yr^{-1}$). Interval sustainability of economic dimension is counted according to equation no. 2:

$$ISuekon = (OI / OImaxabsolut + 1) / 2, \quad (2)$$

where: ISuekon is interval sustainability of economic dimension (%), OI is operating income ($CZK.ha^{-1}.yr^{-1}$), OImaxabsolut is maximal absolut value of operating income in farm group ($CZK.ha^{-1}.yr^{-1}$). Interval sustainability of social dimension is counted according to equation no. 3:

$$ISsoc = PC / PCmax, \quad (3)$$

where: ISsoc is interval sustainability of social dimension (%), PC are personal costs ($CZK.ha^{-1}.yr^{-1}$), PCmax are maximal personal costs in farm group ($CZK.ha^{-1}.yr^{-1}$). Interval sustainability of system is counted according to equation no. 4:

$$ISS = (ISekol + ISekon + ISsoc) / 3, \quad (4)$$

where ISS is interval sustainability of system (%), ISekol is interval sustainability of ecological dimension (%), ISekon is interval sustainability of economic dimension (%), ISsoc is interval sustainability of social dimension (%).

Weighted aggregation is used for calculation of Weighted Interval Sustainability (WIS), which ranges between 0% and 100%. Weighted interval sustainability is counted according to equation no. 5:

$$WIS = \frac{IUDekol * VDekol + IUDekon * VDekon + IUDsoc * VDsoc}{VDekol + VDekon + VDsoc}, \quad (5)$$

where WIS is weighted interval sustainability of farm system (%), ISekol is interval sustainability of ecological dimension (%), ISekon is interval sustainability of economic dimension (%), ISsoc is interval sustainability of social dimension (%), WDekol is weigh of ecological dimension, WDekon is weigh of economic dimension, WDsoc is weigh of social dimension.

TEST OF INDICATORS AND METHODS

The proposed indicators and methods were tested on financial data of chosen 30 farms. Research Institute of Agricultural Economics provided the farm financial data from 1998 to 2000.

1) Test of The Method of Comparison of Indicator Values

Example: Test of chosen group of 30 farms on data in the year 2000. The main characteristics of the chosen group are in Tab. I. Comparison of two chosen farms is in Tab. II. Farm F15 and farm F27 were chosen with random sampling.

I: *The main characteristics of group of 30 farms in 2000*

Indicators	Minimum	Maximum	Average
	CZK.ha^{-1}.yr^{-1}		
Material and Energy Costs	4291	26732	14275
Operating Income	-8320	6333	1075
Personal Costs	2990	15334	7939

II: *Comparison of farm F17 and farm F27 in the year 2000*

Dimension	Indicator (CZK.ha^{-1})	Farm F15	Farm F27
Ecological	MATERIAL AND ENERGY COSTS	25190	16712
Ecological	Technical and chemical services	185	962
Ecological	Fertilisers	1484	2202
Ecological	Plant protection agents	1720	57
Ecological	Seeds and planting stock	702	1650
Ecological	Feeding and bedding	15508	5240
Ecological	Building material and components	629	899
Ecological	Repairs and maintenance	1217	549
Ecological	Water	10	0
Ecological	Fuel	1679	2057
Ecological	Gas	62	95
Ecological	Electricity	1210	693
Economic	OPERATING INCOME	-4	4852
Economic	Revenues from own products and service	50515	38708
Economic	Revenues from plant products	13863	19579
Economic	Revenues from animal products	30500	15827
Economic	Subsidy	4337	3069
Social	PERSONAL COSTS	10605	8263
Social	Wages and Salaries	7700	6044
Social	Social security expenses	2661	2086

Farm F15 is less sustainable in ecological dimension than farm F27. Farm F15 has above-average material and energy costs 25190 CZK. (Average MEC are 14275 CZK in chosen group of 30 farms). Farm F27 is profitable. Farm F15 shows a loss, and this means lower sustainability in economic dimension. Farm F15 spend more money on wages and salaries that means higher support for community in social dimension. Farm F15 is less sustainable in social dimension then farm F15. Both farms have above-average personal costs (Average PC are 7939 CZK in chosen group of 30 farms).

2) Test of The Method of Comparison of Weighted Interval Sustainability

Static variant of the method shows higher or lower sustainability of farms in a year. Example: WIS ranged from 30% to 65% in 2000. Dynamic variant shows change of sustainability in time period. Example: Between 1999 and 2000 the main change of calculated WIS in group of farms was 14%. In 2000 the highest WIS 65% reached farm F30. In the same year system F24 showed the lowest WIS 30%. (See Tab. III).

III: *Sequence of farms according Weighted Interval Sustainability in 2000*

Farm	Ecological Dimension (Weight 3)		Economic Dimension (Weight 2)		Social Dimension (Weight 1)		Farm System
	MEC	ISD	OI	ISD	PC	ISD	WIS
F30	6146	77%	1725	60%	6228	41%	65%
F22	11282	58%	5524	83%	7237	47%	64%
F29	4291	84%	-943	44%	5318	35%	63%
F23	13299	50%	3215	69%	11782	77%	61%
F28	15437	42%	6333	88%	8481	55%	60%
F4	5959	78%	385	52%	2990	19%	60%
F5	9739	64%	2452	65%	4148	27%	58%
F11	9150	66%	-1145	43%	8093	53%	56%
F6	13538	49%	1996	62%	9798	64%	56%
F17	11543	57%	1482	59%	7229	47%	56%
F27	16712	37%	4852	79%	8263	54%	54%
F25	9845	63%	853	55%	3554	23%	54%
F12	7804	71%	-2238	37%	5168	34%	53%
F3	12781	52%	1435	59%	6562	43%	53%
F8	13509	49%	1374	58%	7641	50%	52%
F9	11677	56%	546	53%	5953	39%	52%
F1	13791	48%	948	56%	8016	52%	51%
F18	15389	42%	2367	64%	7546	49%	51%
F16	5500	79%	-8320	0%	8203	53%	49%
F19	14666	45%	602	54%	7375	48%	48%
F13	18098	32%	405	52%	11850	77%	47%
F7	21965	18%	2089	63%	15334	100%	46%
F2	13230	51%	-2308	36%	7487	49%	45%
F20	24219	9%	3334	70%	14401	94%	44%
F10	18000	33%	1236	57%	7532	49%	44%
F26	18038	33%	1417	59%	6810	44%	43%
F14	19487	27%	2269	64%	7231	47%	43%
F21	26732	0%	2477	65%	10377	68%	33%
F15	25190	6%	-4	50%	10605	69%	31%
F24	21240	21%	-2117	37%	6942	45%	30%

MEC - material and energy costs ($CZK.ha^{-1}.yr^{-1}$)
OI - operating income ($CZK.ha^{-1}.yr^{-1}$)
PC - personal costs ($CZK.ha^{-1}.yr^{-1}$)
ISD – interval sustainability of dimension (%)
WIS - weighted interval sustainability of farm system (%)

APPLICATION

The proposed evaluation of relative sustainability is possible to use in decision making at farm or regional level. A way, how to redistribute subsidies for sustainable agriculture support according of change of WIS between years, is proposed. The proposition does not deal with task about which financial source to use, and how much money use for subsidy. Proposed subsidy for sustainable agriculture is calculated by equation no. 6:

$$FS = \frac{SS}{\sum((WIS - WISmin) * A)} * (WIS - WISmin) * A \qquad (6)$$

where: FS is subsidy for farm (CZK), SS is sum of finances for subsidy of farm group, (CZK), WIS is weighted interval sustainability of farm system (%), WISmin is minimal WIS (%), A is farm area (ha).

There is example of distribution of 10 million CZK to chosen 30 farms according financial data in 2000. Amount of subsidy for each farm from group is shown in Tab. IV.

IV: *Example of distribution of 10 million CZK to 30 farms*

Farm	MEC	OI	PC	WIS	Area (he)	Difference WIS and WISmin	Counts WIS	Divided subsidy (CZK)	Subsidy per hectare ($CZK.ha^{-1}$)
F1	13791	948	8016	51%	2151	21%	452	505471	235
F2	13230	-2308	7487	45%	1575	15%	236	264333	168
F3	12781	1435	6562	53%	3064	23%	705	788523	257
F4	5959	385	2990	60%	1490	30%	447	500112	336
F5	9739	2452	4148	58%	1491	28%	418	467144	313
F6	13538	1996	9798	56%	963	26%	250	280130	291
F7	21965	2089	15334	46%	2176	16%	348	389505	179
F8	13509	1374	7641	52%	2503	22%	551	616089	246
F9	11677	546	5953	52%	1211	22%	266	298076	246
F10	18000	1236	7532	44%	1021	14%	143	159924	157
F11	9150	-1145	8093	56%	407	26%	106	118393	291
F12	7804	-2238	5168	53%	1570	23%	361	404005	257
F13	18098	405	11850	47%	1577	17%	268	299870	190
F14	19487	2269	7231	43%	3277	13%	426	476596	145
F15	25190	-4	10605	31%	1337	1%	13	14959	11
F16	5500	-8320	8203	49%	327	19%	62	69576	213
F17	11543	1482	7229	56%	1172	26%	305	341057	291
F18	15389	2367	7546	51%	3209	21%	674	753961	235
F19	14666	602	7375	48%	3302	18%	594	665033	201
F20	24219	3334	14401	44%	2034	14%	285	318574	157
F21	26732	2477	10377	33%	1488	3%	45	49943	34
F22	11282	5524	7237	64%	822	34%	279	312687	380
F23	13299	3215	11782	61%	477	31%	148	165377	347
F24	21240	-2117	6942	30%	1340	0%	0	0	0
F25	9845	853	3554	54%	623	24%	150	167372	269
F26	18038	1417	6810	43%	1279	13%	166	186026	145
F27	16712	4852	8263	54%	1374	24%	330	368995	269
F28	15437	6333	8481	60%	747	30%	224	250569	336
F29	4291	-943	5318	63%	1204	33%	397	444529	369
F30	6146	1725	6228	65%	826	35%	289	323450	392
∑							8938	10 mil.	

MEC - material and energy costs ($CZK.ha^{-1}.yr^{-1}$)
OI - operating income ($CZK.ha^{-1}.yr^{-1}$)
PC - personal costs ($CZK.ha^{-1}.yr^{-1}$)
WIS - weighted interval sustainability of system (%)
VIUSmin - minimal value of weighted interval sustainability in group of farm systems (%)

The example of calculation of subsidy for farm F1 follows:

F1 = (10 000 000 * (51% - 30%) * 2151) / ∑(51% - - 30%) * 2151 = 505471 CZK

Farm F1 received subsidy 505471 CZK according the proposed method.

RESULTS AND DISCUSSION

This research gives two groups of results: methodological results and results from the test of chosen 30 farms. The first group of results contains: the proposal of indication and evaluation method and the proposal of indicators and application. The main result in the second group is sequence of farms by weighted interval values.

The proposed indicators deals with internal conditions of sustainability. The research does not deal with external ecological, economic and social impacts. Increasing sustainability of one farm has positive impact on sustainability of higher level, for example region or landscape.

An optimal measure of aggregation is still a question for discussion. Maximal degree of aggregation is used with aim to make the Index of WIS applicable for sustainable development arrangement. The main weakness of the aggregation is a missing difference between types of inputs and outputs and leaving out many conditions for sustainability. Indicators MEC does not draw a distinction between renewable and non-renewable resources of energy and it does not distinguish between hazardous material and material with lower risk for environment. MEC does not indicate direct impact of outputs on health and environment. Indicators OI does not give information about structure assets and investments. Indicator PC does not distinguish between sources that flow to hired labour and to social security expenses. Despite these negatives, the proposed aggregation is purposeful, effective, and corresponds with sustainable trends.

The proposed construction of indicators is close to indicators, which proposed Levins [1996]. Levins measured: government payment as percentage of gross income, energy and machinery as percentage of gross income, support for local families as percentage of gross income and feed production and use balance. In comparison to Levins, the indicators proposed in this study, transpose material and energy, operating income and personal costs to farm area. Inputs and outputs are in same units ($CZK.ha^{-1}.yr^{-1}$) as subsidies ($CZK.ha^{-1}.yr^{-1}$). This is an advantage for solution of sustainable development. Disadvantage of financial units is that value of inputs and outputs is not close directly to their benefits and risks. There is a common problem of calculation needs of environment, as was pointed out by Chambers in review of Schmidt – Bleek indicators of material intensity per unit of services. [Chambers, 2001] Aggregation calculates same indicators value for example for costs 1000 CZK for fertilisers or 1000 CZK for electricity. Use of more precise partial indicators eliminates mix of different objects, but complicate outputs.

This proposed weighted interval sustainability is applicable in agriculture policy for redistribution of subsidies for sustainable agriculture. Task of sustainability of subsidy is controversial. Unsystematic and irregular subsidy destabilises a system. On the other hand, subsidises are effective tool for strategic management in a market failure situation, for example in the environment – agriculture relationship. The proposal of dividing of subsidy for sustainable agriculture does not expect cancellation of existing subsidies, but suggests redistributing part of these financial sources according to calculated interval sustainability.

CONCLUSION

The main aim of the analysis was to create a tool for sustainable development of agriculture. Proposed indicators shows how farm management supports and stabilises ecological, economic and social dimension and their balance. Analysis shows how farm management corresponds with sustainable trends. Contribution of the proposed method is to substitute laboratory and field research for recycling of existing financial data.

Index of Weighted Interval Sustainability, as compact information, is applicable in decision-making and calculation of subsidies. The main advantages of the proposed method and indicators are system approach, simplicity and inexpensiveness. The main disadvantages are combination of different resources and the absence of some of them in aggregation. The proposed indication and evaluation can be adapted for analysis of other types of human activity.

SUMMARY

The main aim of this research is to propose an evaluation method for measurement of sustainable development in agriculture. The research contains three parts: 1) indication, 2) evaluation and 3) application. System analysis of sustainability contains analysis of ecological, economic and social dimension. An aggregate indicator and a group of partial indicators were selected for each dimension. As the aggregate indicators were proposed: Material and Energy Costs, Operating Income and Personal Costs. Two methods for calculation of relative sustainability were proposed: The Method of Comparison of Indicator Values and The Method of Comparison of Weighted Interval Sustainability. The Method of Comparison of Weighted Interval Sustainability weighed the dimensions by their function and importance in system. There were assigned weigh 3 to ecological, 2 to economic and 1 to social dimension. The proposed evaluation methods were tested on financial data of chosen 30 farms. The Index of Weighted Interval Sustainability ranged from 30% to 65% in the group of farms in 2000. The highest Weighted Interval Sustainability 65% reached a farm with material and energy costs 6146 $CZK.ha^{-1}$, operating income 1725 $CZK.ha^{-1}$ and personal costs 6228 $CZK.ha^{-1}$. The Index of Weighted Interval Sustainability is applicable in agricultural policy with aim to redistribute subsidies according to farm sustainability.

SOUHRN

Analýza udržitelnosti zemědělských systémů

Hlavním cílem výzkumu je navrhnout metody pro měření udržitelného rozvoje zemědělství. Výzkum se skládá ze tří částí: 1) indikace, 2) hodnocení a 3) aplikace. Systémová analýza udržitelnosti obsahuje analýzu ekologické, ekonomické a sociální dimenze. Pro každou dimenzi byl vybrán jeden agregovaný indikátor a skupina dílčích indikátorů. Agregované indikátory byly navrženy tři: materiálové a energetické náklady, provozní hospodářský výsledek a osobní náklady. Pro výpočet relativní udržitelnosti byly navrženy dvě metody: Metoda porovnání indikátorových hodnot a Metoda porovnání vážené intervalové udržitelnosti. Metoda porovnání vážené intervalové udržitelnosti přiřadila dimenzím váhu podle jejich funkce a významu v systému. Ekologické dimenzi byla přiřazena váha 3, ekonomické 2, a sociální 1. Navržené metody hodnocení byly testovány na finančních datech skupiny 30 farem v ČR. V roce 2000 se index vážené intervalové udržitelnosti ve skupině farem pohyboval od 30 % do 65 %. Nejvyšší index vážené intervalové udržitelnosti 65 % vykázala farma s materiálovými a energetickými náklady 6146 $Kč.ha^{-1}.rok^{-1}$, provozním hospodářským výsledkem 1725 $Kč.ha^{-1}.rok^{-1}$, a osobními náklady 6228 $Kč.ha^{-1}.rok^{-1}$. Index vážené intervalové udržitelnosti lze aplikovat v zemědělské politice s cílem přerozdělit dotace podle udržitelnosti farem.

udržitelnost, zemědělství, systém, farma, indikátor, hodnocení

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