SOIL DEGRADATION AND SUSTAINABILITY OF SMALL AND MEDIUM SIZED FARMS IN THE PLOVDIV REGION, BULGARIA

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Abstract

A case study of farming systems in transition in Bulgaria, the Plovdiv region was analysed, with the aim of identifying causalities of environmental and economic performance. The thematic area was soil degradation. State, pressure and management indicators are presented to describe the problem and to identify the causalities and the driving forces.

The case analysed shows a variety of circumstances and environmental problems requiring different measurements and specific indicators. Decreasing intensity of production leads to lower N- and P-losses and lower risk of pesticides residues. However, negative farm gate balances lead, in the medium term, to decreasing soil fertility. Wide areas of abandoned land lead to changes in biodiversity and landscape. The fragmentation of landholdings taking place can be problematic both from the viewpoint of biodiversity management and economic performance.

A trade-off between environmental and economic performance occurs. An unfavourable price relation has also kept farmers income low. Therefore, farmers seem to be more concerned with maintaining liquidity and sufficient income for living than environmental issues. Thus, environmental protection is not a top priority when farmers make their choices, especially those concerning decisions with long-term effects. Break down of irrigation channels has also increased use of ground water for irrigation and thereby increased salinisation.

Keywords: Farming systems, salinisation, transition

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Introduction

The concept of sustainability includes economic, environmental and social dimensions. The sustainability has been threatened also in transition economies when old institutions fall apart and the new ones are still weak. Unstable circumstances like unclear property rights and short term needs and necessities have often prevented actors from taking into account long term effects of their actions. However, the effects of transition are diverse. For example the falling intensity of production during the transition may be beneficial from the environmental point of view. Agriculture is one of the biggest users of land. Agricultural land is an important component of the environment and natural landscape. The soil, as a major subsystem of land, is changing over time as a consequence of changes in its management. Effects of agricultural use on soil can be negative or positive. That depends on the scale, type and intensity of farming as well as on agro-ecological and physical factors, climate and weather. Farming can lead to degradation of soil, water and air quality, and to loss of natural habitats and biodiversity. These environmental changes can result in a substantial decline in agricultural production and food supply, thus limiting the sustainable development of agriculture.

Since 1989 the organisational structure of agriculture in Bulgaria based on large-scale agro-industrial complexes has transformed into one based on privately operated co-operatives and private individual farms. The average size of individual private farms is small but from 1993 to 1996 it nearly doubled to 1.5 hectares. This indicates a shift from subsistence farming toward more commercial production but home consumption and barter still plays an important role in rural economies. Land fragmentation is considered as one of the biggest problems in developing the agricultural production. Land fragmentation and unstable institutional environment have led to an increasing share of unused agricultural land.

In this report we look at the situation in the Plovdiv region in Bulgaria. The Plovdiv region is located in the western part of the Thracian lowland along Maritza River. Plovdiv region has about 480 thousand inhabitants. About 130 thousand of them live in rural areas and more than 69 thousand are engaged in agriculture. The total area of the region is about 170 thousand ha, of which about 150 thousand ha is agricultural land. The mean annual temperature is 11-13 ºC and the temperature sum for the vegetation period 4000-4600 ºC. The annual precipitation is 520-570 mm and atmospheric humidity deficiency is 520 to 320 mm, thus creating a need for irrigation. There are irrigation systems for more than 80% of the land, but approximately 10 percent of this area is actually irrigated (Penov 2001). The Plovdiv agricultural region is characterised by more than ten different types of soil. The main soil types covering 90% of agricultural land are alluvial-meadow soils, chernozem-smolnitza and cinnamon-meadow soils.

Current conditions and the changes during the last years have led to an increase of the share of the medium-sized family farms. They manage integrated farming systems as a combination of plant growing and stockbreeding. A typical middle-sized family farm in the Plovdiv region consists of about 2-10 ha of agricultural land and 5-10 cows. The farms employ on average 2 persons per farm. The production of these farms is very versatile ranging from grains and fodder to vegetables and fruits. Lately there has been an increasing need for specialisation. Large farms specialise in grain production and small ones in more intensive production like fruits and vegetables. Significant changes have taken place in the region concerning the traditional four-field and eight-field crops-rotation. The farm co-operations and the family farms turn back again to the two-field crops-rotation. This change in the crop rotation with reduced and one-sided fertiliser use intensifies the process of destruction of soil structure and leads to lower soil fertility.

The objective of this study is to explore economic performance and environmental impact of middle-sized family farms in Bulgaria and to identify relevant causalities regarding economic and environmental sustainability. Definitions of sustainable farming systems are required to serve as references for impact measurements of alternative systems. In this report, some operational definitions in the form of indicators are presented. Management diversity in agriculture, greater during periods of transition, is commonly recognised. Part of this work was to identify methods for analysing the environmental impact of such diversity and complexity of technologies and management. The farming systems approach allows for a holistic view on the changing situations.

Methodology

The complexity of sustainability as well as the complexity and diversity of farming suggests use of indicators as measures of environmental impact. The use of such indicators reveals the direction of development and may also provide a base for identifying the causes of unsustainable development. Soil parameters, which are a central element of agriculture, change rather slowly and their relation to management is only seen in the long term. The period of transition examined has only been about 10 years, and thus the overall effect of changes in management is hardly yet observable in soils. Use of pressure indicators allows us

to make assumptions not only on the situation (the state) as it is today but also on the long-term effects of a particular technology.
The measurement of sustainability is rather myopic due to transition and uncertainty. The intersection of economic and environmental elements of sustainability gives anthropomorphic elements to ecology. Some of the social elements are included in the economic and ecological sets over time. For example, increasing employment opportunities are reflected as higher costs in agricultural production. Constraints are either set by the ecology or the economy, and these are also at least partly interrelated with time. The economic realities like budget constraints are decisive both at macro and micro levels. External constraints and opportunities connect the farming systems to agricultural policy.

Table 1: State and pressure of soils: impact, indicators and realisation.

Environmental impact	Indicator	Realisation
State		
Soil loss	Water erosion	Soil loss (L) equation – USLE
Salinisation	Salt accumulation in soils	Water soluble salts
Acidification	Chemical reaction of the soil	pH of the soils
Humus degradation	Soil Organic Matter (SOM)	Topsoil assessment
Compaction	Dry bulk density	Textural class
Pollution	Heavy metals, Pesticides	Actual level, Critical level, Non effect level, ED_{50}
Pressure		
Nutrients	Nutrient balance Animal density	Farm gate nutrient balance, livestock units/hectare
Pesticides	Pesticide use	Share of treated area, acute risk index
Irrigation	Water use	Share of irrigated area, share of ground water in irrigation
Cultivation	Cultivation practices	Shallow tillage, burning of straw, crop rotation, choice of crops

Modification of McConnell and Dillon 1997 and Wascher 2000

Dynamic elements are simplified by using sets of indicators that reveal both state and pressure conditions. The indicators collected are problem-specific, reflecting economic viability and ecological sensitivity and resilience for water and soils. The soil is a complex and dynamic ecosystem. Problems related to soil are, erosion, salt accumulation, acidification, organic matter decomposition, nutrient depletion, contamination, loss of biodiversity in soil and soil compaction. State indicators for soils are presented in Table 1. State indicators of soil aim at measuring different aspects of the soil at a given point in time.
Cultivation practices, application of nutrients and pesticides and also water management are driving forces in the changes of agro-ecological systems. Environmental effects build up over time as a consequence of agricultural activities. Nutrient surplus or deficit is measured as a farm gate nutrient balance. The pressure on soil degradation (Table 1.) is evaluated by a system of indicators connected to the intensity of land use and farm management practices.
The indicators of economic performance are presented in Table 2. Productivity of farms is measured by average yield per land or animal unit and by productivity of the resources. Economic results (profitability) of farms are assessed by gross margin (GM), disposable income (DI), net profit (NP) and the rate of return on variable costs (R%). Diversity is evaluated by index of diversity. Stability of agricultural production is assessed by the coefficient of variation (in percent) (CV). Flexibility of farm production is measured by the rate of flexibility (RF). This is the sum of multiplication of share of products and number of

possibilities for their use. Time dispersion is evaluated by relative time-dispersion index (RTD) in man-hours.

Table 2: Selection of criteria for economic performance

Economic Performance		Indicator or proxy
Profitability	Short term, long term	Gross margin, NPV[a], profitability indices
Productivity	Short term, long term	TFP[b], partial productivity
Efficiency [c]		Overall, technical and allocative measures
Risk	Stability, diversity, flexibility and resilience	Coefficient of variation and changes in interest rate, Simpson's diversity index and evaluation of alternatives

[a] Net Present Value
[b] Total Factor Productivity
[c] Efficiency analysis can also be applied to assess environmental performance.
Source: Modification of the setting of McConnell & Dillon (1997).

The sustainable development of farming systems includes not only the economic and the environmental dimension but also the social dimension. Factors like farmers' age, education, land ownership and fragmentation of land indicate partly the social dimension.

Data

The research data from the Plovdiv region was collected as a part of EU-project CEESA (Sustainable agriculture in Central and Eastern European Countries financed by EU Commission DG research). The data are based on two sources. First, results of soil tests and analyses carried out in the villages of the Plovdiv region by the Department of Soil Sciences and the Department of Ecology at Agricultural University of Plovdiv were used. Second, a survey was conducted on middle-sized family farms in the spring 2001. Of the 76 villages in the region, 10 villages were chosen in the study taking into account their position to markets and the level of degradation of soil. The total number of medium-sized family farms in all these ten villages amounts to 2080, of which the sample covers 42 farms. Thus, the sample includes two percent of medium-sized family farms. The sample farms can be classified by specialisation to arable, vegetable and mixed farms (Table 3).

Table 3: Middle-sized family farms classified by specialisation.

Measure	arable farms	vegetable farms	mixed farms
Numbers of Farms	12	11	19
Agricultural land totally ha	145	58	143
-of which irrigated land	65	48	93
Average indicators for farm			
-Agricultural land (ha)	12.1	5.3	7.5
-Respective animals	2.4	2.2	8.1
-Farm workers	1.3	2.4	2.1
-Invested capital (th. BLV)	22.0	17.8	27.3
Total number of animals	29	24	154
-of which cows,	7	5	94
-sheep	82	65	269
-pigs	35	19	57
-poultry	210	170	402
-horses	3	4	12

Results

The share of fields on sample farms is more than 90 %. The highest share (67 %) is under grains, which is due both to possibilities to mechanise the production and to the low production risk. The share of grains is higher on large farms and also on the farms, where more animals are being bred. The specialisation is strongly influenced by the position of the farm to Plovdiv and local agricultural markets. The second important group of crops is forage crops, with silage corn and alfalfa being the main ones. The third group of crops is industrial crops like sunflower, peppermint and anise. They provide a better use of resources (land, labour and machines) and also a higher income per hectare than grains. The share of vegetables and fruits is not very high. These are intensive crops, which require considerable labour and capital input. The area under vegetables is often determined by the farm family's labour capacity. The area under orchards and vineyards increases very slowly because of lack of capital for investments and the uncertainty concerning the development of agriculture.
Animal husbandry is not very widely practised on the medium-sized family farms due to two main factors. First, marketing and price risks are high. For some products, the price fluctuation reached 250 %. The second factor refers to the legal statute and the use of pastures.

State of soils

Table 4 consists of data about the state variables of erosion (USLE), salt accumulation (WSS), acidification (pH) and compactness (VW) of soil for each village and for the whole region. The rate of erosion of soils in the studied villages is low. The soils are either slightly compacted or not compacted at all. Only the soils in the village of Momino selo are highly compacted. From the resilience point of view soil salinisation is critical. The villages may be divided into three groups according to salinisation. The first group includes the villages of Belozem, Radinovo and Graf Ignatievo, where the level of accumulation of salt in the soils is high. High concentration of salts has a negative impact on the growth of some crops. The second group includes the villages with an average level of salt concentration in soils. This moderate concentration of salts is usually a result of secondary salinisation. The level of soil salinisation in the third group of villages is low and the quantities of accumulated salts do not influence the production. The acidification varies from a slightly acid reaction to average acidity in the villages of Radinovo and Momino selo.

Table 4: The state of soils in the ten villages.

Villages	USLE	WSS	pH	VW
Belozem	0.01	1.48	8.75	1.43
Boliarino	0.015	0.35	6.36	1.34
Gr. Ignatievo	0.004	1.03	6.1	1.28
Kadievo	0.025	0.57	6.43	1.14
Krumovo	0.007	0.42	6.13	1.54
Krushevo	0.045	0.4	6.24	1.22
M. Chardak	0.08	0.58	6.35	1.25
Momino selo	0.028	0.62	5.78	1.82
Radinovo	0.065	1.84	5.62	1.18
Skutare	0.008	0.56	6.14	1.3
Average	0.012	0.68	6.17	1.46

Phosphorus content is soil is relatively low, which affects soil fertility. Potassium does not limit the growth of the main crops in the region, since the soils are rich in potassium. Humus content of soils varies from low to average in the studied villages. This relatively low level of

humus contents is linked to the soil type and the intensive use of land for a long time. Accumulated pesticide residues in the soil are decreasing. However, the concentration of heavy metals (lead, cadmium and zinc) restricts the use of land, increases production costs and the risk of product contamination in some areas close to industrial plants.

Pressure on soils

The intensity of production has decreased during the 1990s. This decline is expected to be temporary. The average animal density is low but on mixed farms it exceeds one animal unit per hectare. At present, the average annual deficit of nutrients is 37 kg/ha for nitrogen, 47 kg/ha for phosphorus and 94 kg/ha for potassium. The deficit is highest on arable farms and lowest on vegetable farms (Table 5). Nitrate pressure on ground water is low because of the low use of nitrogen fertilisers. The share of land where pesticides have been applied is relatively low. This may be due to their high relative price, lack of working capital and the influence of the neighbouring fields not treated with pesticides. Therefore the environmental load of pesticides is also low. On vegetable farms two thirds of arable land has been treated. On these farms higher quantities are also used and their acute risk index is higher than on arable and mixed farms. Although the average intensity of pesticide use is relatively low ecological problems may arise due to improper management.
The share of irrigated land of arable land area is largest on vegetable farms (Table 5). On these farms ground water irrigation is also most extensive.

Table 5: Land use and economic and environmental indicators.

Average indicators for farms	Arable	Vegetable	Mixed
Agricultural land (ha)	12.05	5.32	7.53
Livestock units	2.4	2.2	8.1
Farm workers	1.3	2.4	2.1
Land use (%)			
-grains	77	50	64
-industrial crops	13	9	7
-fodder	4	7	20
-vegetable	4	19	5
-permanent grassland	2	15	4
Farm gate nutrients balance (kg/ha)			
-Nitrogen	- 42	- 25	- 34
-Phosphorus	- 49	- 41	- 43
-Potassium	- 95	- 92	- 93
Pesticides			
-Share of treated area in (%)	32.4	67.3	42.8
-Active ingredients (kg/ha)	0.86	2.05	1.14
-Pesticide acute risk index	0.10	0.29	0.18
Irrigation			
-Irrigated land %	45	81	65
-Share of ground water (%)	19	28	24
Economic indicators*			
-Land productivity (BLV/ha)	1724	3272	1885
-Off-farm return on input	1.56	1.82	2.14
-Farm gross margins (BLV)	4 748	6 948	5 182
-Invested capital (th. BLV)	22.0	17.8	27.3
-Net farm Income Ratio (%)	29.8	18.6	23.4
-Rate of revenue diversity	0.48	0.55	0.59
-Revenue variation (%)	27.6	21.8	18.2
-Rate of flexibility	0.37	0.44	0.56
-Rate of time dispersion	36.5	28.9	21.3
-Self-sufficiency (%)	11.2	10.8	12.6

*Calculation as in McConnell & Dillon (1997)

Use of ground water for irrigation leads to an increasing risk of salinisation of soils. It is particularly risky to use ground water for irrigation in territories when the level of soil salinisation is high, as in the villages of Belozem, Radinovo and Graf Ignatievo. The main reasons for increasing use of ground water are the destruction of canal system, the price of irrigation water and the willingness to look for technological independence. Lack of knowledge concerning the long-term consequences of ground water irrigation is also evident.

Economic indicators

The development of medium-sized family farms is conditioned to their economic status and production potential. They are the basis for increasing sustainability of the production system and also for improving the technologies. The medium-sized farms cannot provide the income, necessary for the development of farm at current yields and price relations. To maintain liquidity managers are forced to cut such spending as insurance, soil tests, etc. The family's disposal income is often insufficient for living expenses. This is a reason for the family members to look for work outside the farm. Most of the farmers are inclined to decrease their production if they succeed in finding another job.
The diversification is an important factor of the sustainability of farming systems. The diversification of the assets, production, incomes and returns is high. This high diversification is on some farms a limiting factor for the whole farm profitability. It is necessary to find the balance between economies of size and scope. Opportunities to utilise the economies of size increase in accordance with the growing stability of the national economy.
The flexibility of production on medium-sized family farms is close to the average of the region and the country as a whole. The great variety of products, as on mixed farms has a positive effect on flexibility. This effect, however, is limited by the absence of marketing opportunities of products, which are produced only for farm family's consumption.
The distribution of labour on medium-sized family farms, is an important condition for effective labour use. The labour engagement during the years is assessed by the indicator time-dispersion index. The distribution of labour is comparatively more even on the farms with a high share of cattle breeding. On the specialised crop farms, the distribution of labour is especially uneven. The size and structure of the labour resources exert particular effect on the way they are being used within the farm.

Management

Marketing opportunities of produce and effective use of own resources have a priority when making decisions on middle-sized farms. The objectives of about 64 % of farmers are directly connected to their market position. Most of the rest of the farmers consider agricultural production as a temporary or additional activity. The level of self-sufficiency in agricultural products on these farms is high.
One of the main factors affecting the sustainability of middle-sized family farms is the fragmentation of agricultural land. Sample farms cultivate from 4 to 15 parcels of land locating all over the village. The average size of the parcel is 1.2 ha, but there are parcels with the size of 0.3-0.4 ha. This fragmentation of arable land has an influence on the quality of farming practices. The costs of cultivation of small parcels may grow above the value of production. In this case the fragmentation of land increases the share of abandoned land. The opportunities of utilising technical progress are thus limited. Land fragmentation also contributes to the destruction of the irrigation canal system. The share of irrigated land on middle-sized family farms has decreased in the last years. More and more farmers have

increased the use of ground water for irrigation. This leads to an increasing risk of salinisation of soils.
The lack of soil tests might increase the risk of negative effects on the soil, e.g. when inappropriate amounts of fertilisers are applied. Farmers have also difficulties in maintaining crop rotations. The burning of straw, which is linked to one-sided crop rotation, destroys soil quality, degrades humus and produces negative effects on biodiversity. Disking has in many cases substituted for ploughing, increasing the risk of compaction and wind erosion. Shallow tillage also increases the negative effects of salinisation.
The share of the farmers at the age of retirement is high. The share of farmers at the age under 40 is only 12%. The professional education and the practical training of farmers is often insufficient for adopting new technologies. Approximately 20% of farm workers have agricultural education. The farmers face difficulties in their decisions about suitable varieties, fertilisation and pest management.
The sample farms have been established several years ago. Most of them are in the process of restructuring and specialisation. However, the goals of farmers are still mostly short-term goals. The concentration on short term planning limits the possibilities to take into account environmental impacts of agricultural activities e.g. on soil degradation. The process of transition has to lead to more stable economic environment in the country.

Discussion

From the assessment of the state of soils in the Plovdiv region we are able to conclude that the soils in the region are only slightly eroded and the risk of increasing rate of erosion is low. Acidification of soil has an unfavourable effect on farming. The acidification of soils is typical for the region. Soil compactness is with some minor exceptions not a problem in the region. From the sustainability and especially the resilience point of view, salinisation of soil is a critical problem. Salinisation of soil influences considerably the production possibilities and yields in some villages. Also the destruction of irrigation canals due to low marginal returns and institutional arrangements have resulted in increased use of ground water resources and, as a consequence, the risk of secondary salinisation.
Problems occurred during the collection of the survey data. For instance many of the selected farms have not taken soil tests. In these cases tests from other farms in the same area were used. Land fragmentation and great number of plots on the farm have often rendered difficulties when accounting some items, like tillage, fertiliser use, average yields, etc. For this reason only average values or predominant farm activities have been considered. In addition, lack of accountancy for input-output and cash flows necessitated additional use of expert assessment. The farmers have not always provided sufficient information due to a fear of administrative consequences (duties, fees, penalties, etc.).
Agriculture in the transition countries has become more extensive since 1990 (Tanic et al 2001). Due to unfavourable price relations and somewhat ambiguous ownership status, production technology has changed. This has led to a reduction in the environmental burden caused by, for instance, the harmful effects of excessive use of fertilisers and pesticides. However, the outcome of enforced low input agriculture is not only positive. The farmers main concern is often to maintain liquidity and sufficient income to cover cost of living. Short-term goals or needs are dominant in decision-making, with long-term objectives, receiving lower priority. There is also a need for developments in extension service.

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