FARMING SYSTEMS AND RURAL COMMUNITY WELFARE FROM AN ENVIRONMENTAL PERSPECTIVE. A CASE STUDY ON AGRICULTURAL NONPOINT SOURCE POLLUTION IN ROMANIA

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Abstract

The paper analyses the impact of farming systems on water quality. Agri-environmental indicators are used as tools to describe the relation between agriculture, rural development and environment. The analysis is performed at farm and rural community level, based on farm survey data and water quality assessment in two 'receptor points', upstream and downstream the critical region.

Keywords: farming systems, agri-environmental indicators, nonpoint source pollution.

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1. Introduction

The paper focuses on agri-environmental indicators at micro level, to measure the impact of farming systems on environment in a Romanian agricultural region. The analysis is performed at farm and rural community level (Cazanesti commune crossed by Ialomita River -south-eastern part of Romania), based on farm survey data (collected during April 2001 – CEESA survey) and water quality assessment in two 'receptor points', upstream and downstream the critical region.

The specific problem that the case study deals with is nonpoint source pollution of water with discharges from agriculture (nitrogen, phosphorus and waste from animal farms). Nonpoint source pollution problems refer mainly to emissions by small sources (in our case, farms) and include nutrient pollution, pesticide pollution, sedimentation, and hazardous and solid waste. Many nonpoint sources of pollution are insignificant, while other sources contribute substantially to watershed damage. Topographic, hydrologic, and agronomic factors often combine to make some nonpoint sources more detrimental to the beneficial use of water resources than others.

The environmental situation in the case study area is poor as regards to water and soil pollution from agricultural sources. The main water polluting source in the area is livestock farming that has contributed to high bacteria and nutrient levels in surface and ground water.

There are different farming systems well represented in the region (vegetal farms, livestock farms and, from the ownership point of view, there are private farms – family farms, family associations and legal associations, state farms). Most polluting farms are associations and state farms. Also, the number of livestock is larger in state farms than in family farms, still the last ones are also very likely to pollute depending on their distance from the watershed, stable facilities, and mainly because few of them have manure storage facilities.

Main reasons for agricultural nonpoint source pollution are related to: low farmers' financial means to apply environmentally friendly agricultural practices; low farmers' environmental awareness; lack of financial incentives and/or environmental regulations to deal with NPS pollution from agriculture. This paper presents the results of the analysis of the agri-environmental indicators. These indicators are used for agri-environmental analysis and monitoring along with evaluation and improvement of agricultural and environmental policies.

2. Methodological issues

Farm survey

A questionnaire was compiled for household farms, comprising statistical data on farm and farmer characteristics. A specific set of questions was directed to farmers' awareness of water quality issues and their interest in learning more about water quality. Besides, a similar questionnaire was applied to agricultural associations and agrifood companies.

A community questionnaire comprised general data on commune's economic, social and environmental characteristics. Related to the last point, questions focused on household waste collection system, sewage, frequency of environmental controls, state of commune pasture, general environmental awareness of inhabitants, environmental accidents.

Data collection was done by questionnaire based interviews to 99 household farm managers in the case region, managers/ representatives of 5 farm associations, 1 private dairy company and the largest livestock farm were interviewed. The investigation took place in April 2001 in Cazanesti commune, Ialomita county, Romania.

Agri-environmental indicators.

The paper uses partially the OECD agri-environmental indicators (OECD, 2001) that examine the impact on agri-environmental relationships of farm socio-economic characteristics; indicators on farm financial resources that illustrate the relationship between financial resources and farm management practices; farm management practices indicators; and nutrient management indicators.

Societal preferences.

Societal preferences relate to farmers' awareness and concern about agriculture's impact on environmental quality, in terms of increasing agri-environmental efficiency (reducing pollution and enhancing benefits from agricultural activity). In order to estimate the relationship between farmers' environmental awareness and characteristics of farmers and farms, we solve a logit model using maximum likelihood estimation (MLE). MLE seeks to maximise the log likelihood, which reflects how likely it is - the odds - that the observed values of the dependent variable may be predicted from the observed values of the independent variables.

The dependent variable represents farmers environmental concern (societal preferences) constituted as a function of five variables concerning farmer's interest/ acknowledgement in environmental quality and protection. The dependent variable 'concern' is a dichotomous variable taking value 1 for farmers with environmental concern (at least two of the constituting variables taking value 1) and value 0 if else.

The explanatory variables refer to farm characteristics (assets, use of agricultural services, membership in agricultural association), and farmer characteristics (socio-demographical indicators, agri-environmental information access, investment behaviour). The choice of independent variables lies on the economic and social aspects of the model, as it is preferred not to use statistical methods for selecting them.

Environmental impacts.

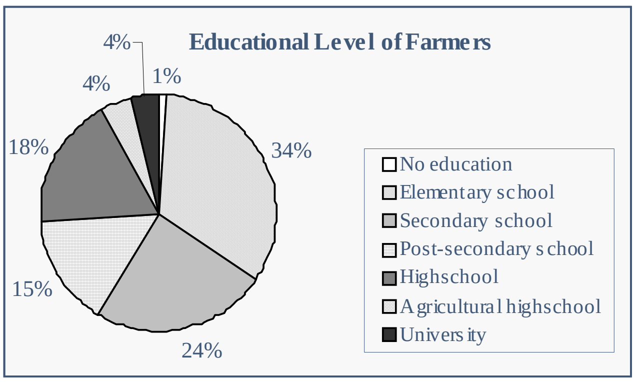
The principal sources of water pollution from agriculture include nutrients, and organic, biological contaminants associated with agriculture. The key areas of concern regarding the state of water quality relate to nitrate pollution in both surface and groundwater; phosphorus levels in surface water; the level of contamination with pesticides. The indicators are expressed as the proportion of sampled concentrations of nitrate and phosphorus above national standards. Information on Ialomita River quality upstream and downstream the critical area was collected by the National Company “Romanian Waters”. Physical and chemical characteristics of water (presence of nutrients, PO_4^3, $NO2^-$, NO^{3-}, NH^{4+}, and major ions, Cl^-, K^+, Na^+, as well as chemical oxygen consumption, CCO-Mn, biochemical oxygen consumption CBO_5 and other components concentrations) were measured.

Results

Farm socio-economic characteristics.

The number of farms and the farm size have remained relatively constant during the last decade. Most private land is cultivated in associations, leading to concentration of production in a small number of large agricultural associations. The share of large household farms is insignificant (only 4 households own more than 10 hectares). There are 1100 rural household farms (average size of 3.74 hectares and an average number of plots of 1.83), 3 legal agricultural associations (average size of 914 hectares) and 1 family agricultural association (size of 73 hectares).
Cazanesti is favourable for arable crops, while vineyards and orchards are only slightly represented due to less auspicious climate and soil conditions. About 97 per cent of agricultural land is used for arable farming, 2 per cent is under permanent pasture, vineyards and orchards account for about 1 per cent. There are hardly any changes in agricultural land use during the last decade. The number of livestock farms (mainly dairy farms) is increasing. Local dairy farming is developing fast. Some prospected projects on organic farming at large scale might, partially solve the high unemployment while on the other hand, trigger a change in agricultural land use to less intensive.
Average age of the household farm manager is 57 years (and 49 years for agricultural association manager), with a minimum value of 23 and a maximum of 85, and 34 years, respectively, 62 years in the case of associations. Male farmers predominate (65% for household farms and, respectively, 100% for associations). The fact that more than half of the farmers (59%) are over 55 years old, is not an encouraging sign to potential long-term viability of agriculture, given that younger well-educated farmers are more likely in favour of changing economic and environmental conditions. The low average age for association managers is directly related to entrepreneurial behaviour and managerial skills.
The fact that 26% of farm managers have finished at least highschool is an encouraging sign as regards to their being forward-looking to changes (Figure 1).

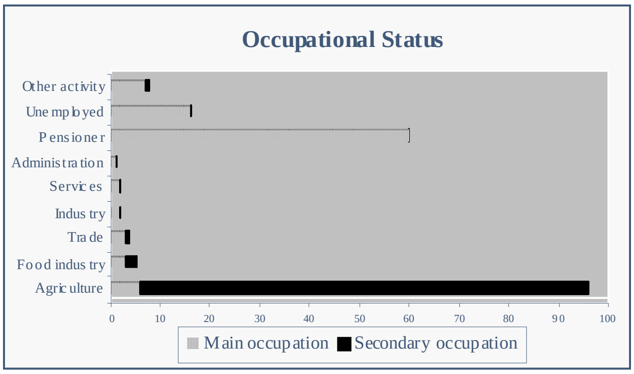
Figure 1: Share of Farmers by Educational Level



Source: CEESA survey Cazanesti, April 2001

The classification of farmers based on their main and secondary occupations is shown in Figure 2. The high percentage of pensioners (60%) and the high unemployment (16%) are clearly indicators supporting the discussion above related to farmers' age and their incentives to act environmentally friendly. The low percentage of farmers with a main agricultural occupation is characteristic to the high number of pluriactive households. Nevertheless, almost all farm managers are occupied in agriculture, considering it as their secondary job (this is consistent to the high number of pensioners corroborated with the time spent in agriculture). This is further underlined by the time spent in agriculture (over two thirds spend more than 75% of their time in agriculture).

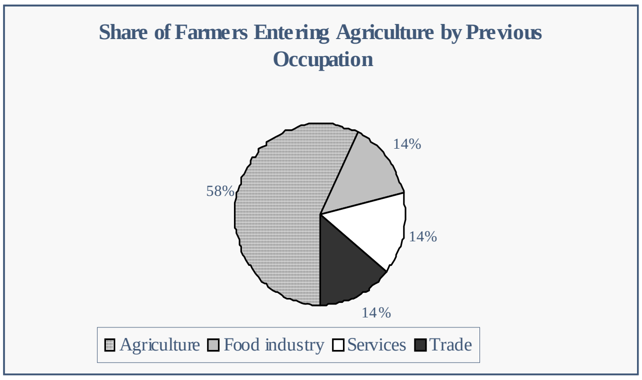
Figure 2: Classification of Farmers by Occupational Status (CEESA survey Cazanesti, April 2001)



Source: CEESA survey Cazanesti, April 2001

As shown in Figure 3, out of farmers 58% have preserved their occupational status, the others were previously employed in food industry, services and trade in equal shares of about 14%. The previous non-agricultural occupation is consistent with the high unemployment in industry and services. The relationship is less clear between this indicator and agri-environmental concern of farmers. In principle, the fact that more than half of the farmers have been always occupied in agriculture would mean a higher experience and a higher probability that they are applying better agricultural practices.

Figure 3: Share of Farmers Entering Agriculture by Previous Occupation (CEESA survey Cazanesti, April 2001)



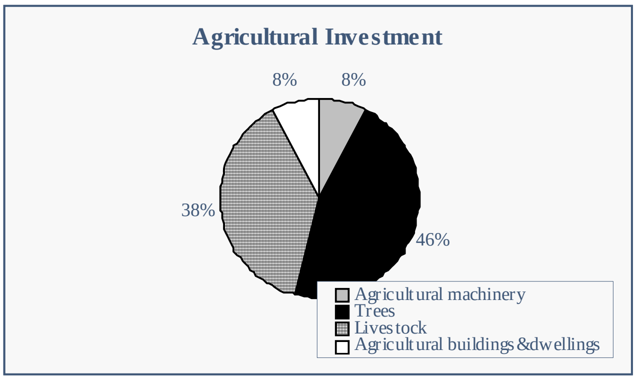
Source: CEESA survey Cazanesti, April 2001

The number of workers hired by the farms on a permanent or temporary basis and labour exchanged with other household farms might provide evidence of farm economic viability. Household farms hiring exchanging labour keep a larger than average number of livestock (12.2 livestock heads compared to 4.83). The survey results show that 9% of household farms hire labour force and 5% exchange labour with other households. Related to dairy farming, 100% of farms that own more than 3 cows hire labour, and there is a significant correlation between the number of cattle and number of hired labour (Pearson is 0.52). Therefore, a high number of workers associated with dairy farming has even a stronger meaning in an environmental context, considering that dairy farms imply less intensive farming.

Farm financial resources.

There is no public or private funding on agri-environmental issues at farm level in Cazanesti. There has been an initiative for organic dairy farming, but it has not received any funding yet.
The agricultural investment behaviour of farmers is computed as the share of farms that invested in agriculture (land, equipment, buildings and dwellings, livestock, etc.). The sample shows 26.6% farmers with positive investments, among which, half invest in agriculture (Figure 4).

Figure 4: Classification of Household Farms according to Their Investment Behaviour (CEESA household survey, April 2001)



Source: CEESA survey Cazanesti, April 2001

The average agricultural investment is lower by two thirds than the non-agricultural one. The investment target is livestock (38%), and machinery and dwellings (16%). Agricultural investment structure presents a low financial profile of household farms in the sample, own funding being directed to less expensive investments. Moreover, no bank credit underlines this characteristic as it implies farmers' risk-aversion and scarcity of collaterals.

Farm management and the environment.

There is no organic farming in Cazanesti, although some attempts have been made to create organic farms in Cazanesti area. At present, there is a private initiative to establish an organic dairy farm. The initiative is feasible as local dairy farming has started to develop and labour force is available at low cost. Farmers interviewed are willing to switch to organic farming, if conversion costs would be subsidised.
According to OECD criteria, Cazanesti sample has no farms with nutrient management plans. Associations are applying chemical and organic fertilisers without precise measurement of crop uptake. The fact that each association employs an agronomist (on a permanent or temporary basis) insures a reasonable understanding of crop needs and nutrient availability at different growth stages in order to efficiently meet these needs with nutrient applications. Still, practical circumstances (availability of cash or credit to buy inputs, pressure from landowners to cultivate some more profitable crops - sometimes against a proper crop rotation-, low funding for soil testing, etc.) overcome scientific knowledge.
Cazanesti area has had a low-efficiency irrigation system, based on flooding. Still, it is almost completely deteriorated and has not been used in years. Flooding technology is the least efficient type of irrigation system and implies high risks of environmental effects.

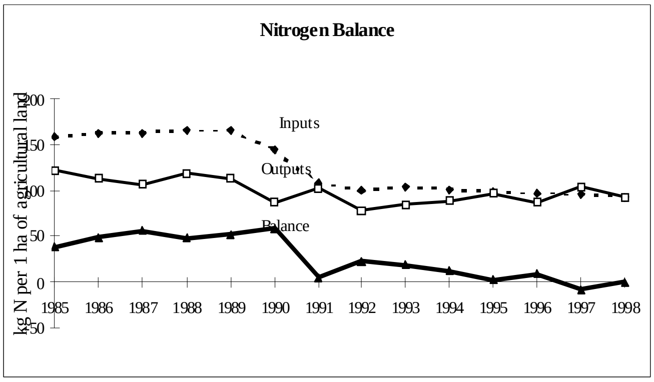
Use of farm inputs.

At national level, substantial reduction of nitrogen surplus was driven by such transition phenomena as the sharp decrease in cattle numbers, implying the fall in application of organic fertilisers and reduction in use of inorganic fertilisers; neglect of proper crop rotations, etc. These were triggered by the fall in output due to reduced food demand, collapse in agricultural support levels, the downsizing of input subsidies and increasing debt levels in the farm sector.

The spatial variation of nitrogen surpluses can be considerable. Regional data suggests that even in countries with a relatively low national nitrogen surplus, nitrate pollution is experienced in some localities, while soil nutrient deficits occur in others.

The soil surface nitrogen balance for Romania (Figure 5) was calculated in accordance with OECD methodology (Toma, 2000).

Figure 5: Nitrogen Balance



Source: Own calculations based on OECD methodology

It indicates substantial reduction of nitrogen surplus due to sharp decrease in cattle numbers, implying the fall in application of organic fertilisers; reduction in use of inorganic fertilisers; neglect of proper crop rotations. The trend in the nitrogen balance signals the potential problem of sustainable use of agricultural resources.

The average nutrient use in the sampled area in year 2000 was between 100-150 kg NPK per hectare for legal associations and 60 kg urea per hectare for family association; there are no exact figures on manure application. As the nutrient use has decreased constantly during transition period, the fact that regular sampling of groundwater (wells) indicates a nitrate concentration above maximum allowable limit (10 NO_3 mg/l) might have the following causes:

- First, groundwater pollution remains contaminated for many years, lagging behind the decreasing trend of chemicals use. This is supported by the fact that Ialomita River has shown a decreasing trend of nitrate and ammonium pollution on the section corresponding to Cazanesti area (although still included in the 'damaged water' category as regards to concentration of other pollutants - see below indicator 'water quality'). Surface water is refreshing relatively rapidly.
- The type of cropping/livestock system; for example, the pattern of disposal of manure from livestock farms shows little concern to manure storage restrictions.
- Farm management practices, including the timing and method of nutrient application and storage.

Pesticide use fell drastically in the first years of transition and continued to decline in most recent years. Within the sampled area, the use of pesticides in year 2000 was on average 1 kg active ingredient per hectare.

Societal preferences.

Logit model's results are consistent with the empirical side, as the significant independent variables have obvious potential impact on farmer's environmental awareness. While farm characteristics are found less significant (except for storage facilities, that stands for a better financial status of the farm), farmer's characteristics selected by the model (educational level, secondary job and access to agri-environmental information) would be selected also based on empirical evidence.

This analysis adds to the deductions based on indicators discussed above. Farmer's education, occupation, and agri-environmental information access have evident impact on his environmental awareness. Gale et al. (1993) hypothesised that younger farmers, with greater access to information sources, are more likely to adopt conservation practices. Availability and use of information and assistance can be an important determinant of farmers' willingness and ability to adopt new agricultural practices. Mass media sources are important for building awareness of an innovation. Farmers tend to rely on farm associations to evaluate an innovation and decide whether to adopt it. Information about new public policies is especially important because of the uncertainty and complexity often associated with changes required by new programs. Gale et al. (1993) argues that farmers need education to recognise pollution problems and to learn how best agricultural practices can be used to reduce the severity of pollution. It has been found that farmers who used more institutional sources of information, on a more frequent basis, tended to be more concerned about environmental issues in their decision making.

Environmental impacts.

Ialomita River is polluted (water quality is included in "degraded" category) on a segment of more than 250 km between the confluence with Cricov River and confluence with the Danube. Although the degree of pollution has shown a decreasing trend after 1990, Ialomita River is still the second Romanian River as regards the percentage of "degraded" water in total river length. Out of the 19 monitored sections, 11 sections (representing 45% of the river length) belong to "degraded water" category. The share of degraded water in total length of monitored river has decreased from 57.66% to 29.45% due both to lowering industrial pollution (closure of industrial plants) and decrease in pollution from agriculture (due to lower consumption of chemical fertilisers and pesticides, decrease of livestock). The change in river water quality does offer some evidence on relationship between water pollution and farming systems practices, although the river section we study is still highly polluted.

The main agricultural pollutants in the sample area have been chemical and organic fertilisers and pesticides. The decrease in the use of chemical fertilisers in 1990s was an important factor in reducing water pollution in recent years. Pollution from organic fertilisers has also diminished due to the smaller livestock numbers. Therefore, figures present, on average, concentrations below maximum allowable limits in surface waters, but still excess of pollutants in groundwater. This is explained by a slower process of self-decontamination of groundwater. The extent of groundwater pollution from agricultural nutrients is less well documented than is the case for surface waters, largely because of the cost involved in sampling groundwater. Moreover, correlating nutrient contamination levels in groundwater with changes in farming practices and production systems is difficult, because it can take many years for nutrients to leach through overlying soils into aquifers.

Groundwater in the sampled area is high in nitrates content (due to agricultural leakage). Sanitary controls have concluded that water from wells exceeds maximum allowable limits in pollutant concentrations (mainly nitrates) and is not drinkable either by humans or livestock. There has been recently established a public water supply, so far 180 households benefit, in time the whole community will have access.

The increase in concentration of substances exceeding maximum allowable limit (MAL) detected between the two receptor points on Ialomita River is caused by both agricultural and non-agricultural sources in the sampled area – livestock and crop farms, and household waste disposal –, which both affect environment but at different levels.

There is a clear understanding (based on Environmental Protection Agency regular controls in the area) that the main polluter of Ialomita River has been the recently-liquidated pig farm, SuinProd Cazanesti. Other livestock farms, and improper disposal of livestock manure and household waste are contributing much less. Overall, the main pollution problem has been diffuse-source contamination of water resources with livestock waste.

The area has had until recently (SuinProd enterprise's closure earlier this year) high cattle and pig stocking densities (1,136 large livestock units per hectare). The degradation of waste treatment equipment (storage and discharge holding basins for an average of 200,000 pigs) in the main livestock complex during the 1990s has been an acute problem. The waste treatment plant was placed in the neighbourhood of the community pasture. The liquid waste from the pig complex was discharged frequently into Ialomita River in semi- or untreated form, high in suspended solids, ammonia, and pathogens. Although the pig farm was closed in 2001, effects will be overcome only after a while.

As regards to the other pollutant sources, household and livestock waste are dumped together on the two waste platforms of the commune, despite regular controls and attempts made by the regional environmental agency to induce separate waste disposal. Private livestock farms registered as commercial farms respect environmental rules as there is a regular assessment done by environmental agency and other bodies (sanitary-veterinary checks). Farmers who have recently started to operate in livestock farming and have not yet registered as commercial farms do not fully respect environmental rules. This is also the case of farms with lower number of livestock.

Manure is typically stored in open or closed piles sometimes of small size and poor construction quality, generally close to the stables and/or agricultural dwellings. The nearness of the wells used to supply drinking water and flush slurry pits to these pollution sources may result in contamination. Or, as presented above, they store the manure on arable land, garbage platforms or on communal pasture with no concern for proper timing, placement, etc.

In order to assess potential contamination by manure, one can assume that any conditions under which application of the waste induce the soil's water storage capacity being exceeded, will likely lead to pollution of water resources. The highest usable rate of this waste essentially depends on the pedoclimatic conditions prevailing at the time of application. When the field capacity of the soil is overcome, whether due to high manure quantities or because the application/ disposal is followed by raining (or flooding – Ialomita River has flooded often at winter time), draining inevitably appears. Also, the infrastructure of manure storage pits near water wells, obviously affects drinking water. The factors to control and lessen the polluting effect of the manure are closely related to both the nitrate absorption capacity of the crop and the ammonium binding-adsorption capacity of the soil exchange complex. Similarly, the polluting effect of the slurry is lessened or at least delayed when, under specific weather and soil conditions, applied nitrogen is lost through denitrification and volatilisation.

In the sampled area, 28.3% of the survey respondents consider that drinking water quality in the commune is impairing human health, 63.6% cannot appreciate, 8.1% do not answer. Out of farmers 44.4% uses pasture (there is a long strip of pasture following closely Ialomita River) on average 6 months per year for livestock grazing. Out of them, 60% consider that pasture quality is poor, either due to poor maintaining or pollution. Veterinary services is used by 15.5% farmers for cases of livestock indigestion caused by infested drinking water and 20% for other livestock diseases, besides the regular vaccination. Related to household waste disposal, 80.8% declared to use community garbage platforms, the rest store it in their backyard and burn it later on. Livestock waste is disposed on the same community garbage platforms by 71.7% of farmers, 13.1% in their own backyard, 14.1% do not answer and 1% use it as organic fertiliser.

"*Romanian Waters*" (Romanian Waters, 2001) takes samples regularly and examines the presence of nutrients (PO_4^3, $NO2^-$, NO^{3-}, NH^{4+}) and major ions (Cl^-, K^+, Na^+), as well as several other chemical components concentrations. Samples are obtained monthly (around the 15th of each month) from receptor points on Ialomita River. According to different chemical component concentrations, water quality has been assigned to different quality categories. Among the chemical components whose level might have been increased due to agricultural sources (livestock and crop farming) in the sampled area, the maximum allowable limit for fixed residues, Cl^-, and Na^+ was exceeded, on yearly average, as to place these concentrations within 'degraded water' category.

Some chemical components that, on yearly average do not exceed maximum allowable limits as to be included in 'degraded water' category (although they are included in the 2nd or 3rd categories, unfit for livestock consumption and aquatic fauna), record values above MAL during some months, showing a likely relation between water quality and livestock waste disposal from SuinProd (reported as accidents and penalised by the environmental agency), and application of fertilisers during spring and autumn agricultural operations. As for timing the effects of improper household waste disposal and livestock waste disposal from unsupervised farms, it is an impossible task (as they are not in permanent supervision of environmental agency or local authorities).

Parameters indicative of salinity (fixed residues, Cl^-, Na^+) exceed MAL on an yearly average. These are elements whose concentration is strongly dependent on dilution by rainfall, which is another factor to explain for variability of concentration in time. Doing a multiple correlation analysis, we conclude a very strong correlation between these parameters (Pearson takes values between 0.87 and 0.97), strongly suggesting a common origin for these groups of variables, in our case, livestock waste. Based on the results of the bacteriological analyses performed in wells sampled in 2000, the wells were under strong bacterial contamination and their water was thus unfit for drinking over more than 80% of the period.

Conclusion

The analysis on agri-environmental indicators in the case study area revealed a typical picture of the Romanian farming systems' development during the last decade, that have led to contradictory impacts on environmental situation, in our case, water pollution. The depreciation of farming systems economic situation led to a decreasing inputs use, low use of machinery, decreasing livestock numbers, thus decreasing water pollution from agriculture. On the other hand, lack of financial means led to ignorance of environmental conservation and abandonment of unproductive land. Use of old machinery with defective impact on soil quality, improper crop rotation, all these factors led to increasing water pollution.

The main polluter in the area has ceased to operate and an increase in water quality is expected in short-to-medium term. Still, sustainability in the region depends entirely on farmers' environmental awareness and legal and financial means to support it.

Against background of lacking market orientation and of low income generated by agricultural activities, the majority of family farms play mainly a social function of providing means of survival for rural and, partly, urban population. Their future economic viability as agricultural producers seems to be rather limited. Their concern in environmental issues and their involvement in sustainable farming is low. From the point of view of low use of fertilisers, pesticides and use of heavy machinery, individual farms are the least important polluters from agriculture. Nevertheless, even small-scale agriculture leads to pollution through improper crop rotation, lowering soil content of nutrients, set-aside land that needs amelioration works. In the long run, household farming systems are to operate at a larger-scale (due to land market developments) and not as subsistence agriculture, and thereby their impact on environment will increase.

From the environmental point of view, lack of financial resources has led most farmers (both family farms and many associations) to think less of sustainable farming but of short-term profits, with little concern to environmental damage that might hinder farming systems development on the long run.

The situation changes in the case of some emerging private companies. Although a small number, these companies demonstrate the potential for rapid development of agribusiness in Romania, provided that reliable markets are found. These private companies are also more concerned about environment, being aware that sustainable way of farming is going to increase their profits in the long run. In the short term, no significant changes will take place related to farming systems means and awareness to deal with environmental issues.

These initial results, combined with the outcome of the following methodological stage are to be later on developed into a set of recommendations. Tentatively, we mention:

- Adoption of best management practices at farm level (environmental friendly); these would include reduction of barn waste, animal waste management (manure storage and management), diversions, grazing land protection;
- Designing local participatory strategies to co-interest agricultural producers in reducing agricultural NPS pollution. One side of the participatory issues would relate either to subsidies/direct support to farmers who would adopt environmental friendly agricultural practices or to state environmental regulations if the problems would not be solved through voluntary NPS control measures;
- Proposing strategies for a better inter-agency co-operation (e.g., the relationship between environmental protection agencies, agricultural consultancy agencies, agricultural directorates, farmers associations, local authorities, local NGOs);
- Designing an effective information and education program for farmers; make results available to the community to enhance public education and contribute to more effective management of water quality problems in the future.

These can be used for policy makers as tools for designing and implementing regulatory instruments in the field of agri-environmental policies both at local and at national level.

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