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Family dairy farms in the Podlasie province, Poland: farm typology according to farming system

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Abstract

The aim of this paper is to establish a farm typology according to the dairy farming systems in the western part of the Podlasie province. Data of 39 variables was collected by a survey to owners of 123 family farms. A two-stage multivariate analysis was conducted in order to determine farm typology. Three principal components were detected, explaining 80.4% of the total variance. The cluster analysis identified five groups of farms. In two groups the cow productivity is the biggest in the area. A third group contains the smallest and lowest cow productivity farms, with high proportion of non-agricultural activities. One of the two remaining groups has better soil quality and medium cow productivity. The other group has low or medium soil quality but cow productivity is higher than in the fourth group. The SWOT analysis shows different weaknesses and strengths for different groups, as well as those common to a larger number of groups. Weaknesses are related to small farm size, large number of workers, low or medium soil quality and low or medium level of technology. Strengths are related to a large share of fodder crops, low livestock density, diversification of agrarian activities and acceptable cow productivity. On the other hand, general opportunities are linked to the EU-CAP evolution and to the presence of cooperatives in the region, whereas general threats derive from a hypothetic increase of feed prices and quantity of milk produced in the EU, which could lead to a fall in milk prices.

Additional key words: cattle density; farming diversification; multivariate analysis.

Resumen

Explotaciones lecheras familiares de la provincia de Podlasia (Polonia): clasificación de las explotaciones según los sistemas agrarios

El objetivo de este trabajo es establecer tipologías de sistemas lecheros en el oeste de Podlasia (Polonia). Se analizaron 39 variables a partir de encuestas realizadas a propietarios de 123 explotaciones. Tras el análisis multivariante en dos etapas (factorial y cluster) se encontraron tres componentes principales que explican el 80,4% de la varianza total y se obtuvieron cinco grupos de explotaciones. En dos de los grupos la productividad de las vacas es la mayor de la zona. Un tercer grupo tiene las granjas más pequeñas y menos productivas, con una mayor proporción de actividades no agrarias. El cuarto tiene los suelos de mejor calidad y una productividad de las vacas media y el quinto tiene suelos de calidad media o baja pero una productividad de las vacas superior. En general, las debilidades están relacionadas con una escasa dimensión de las granjas, un elevado número de trabajadores, una baja o media calidad de los suelos y un bajo o mediano nivel de tecnología. Las fortalezas están relacionadas con la abundancia de cultivos forrajeros, una carga ganadera baja, una aceptable diversificación agraria y una aceptable productividad de las vacas. Las principales oportunidades están ligadas a la evolución de la PAC de la UE y a la presencia de cooperativas para la comercialización de la leche. Las principales amenazas derivan de los posibles incrementos de precios de los alimentos para el ganado y de leche producida en la UE, que puede conducir a una caída de los precios de venta de la leche.

Palabras clave adicionales: análisis multivariante; carga ganadera; diversificación agraria.

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Introduction

Policy decisions oriented towards sustainable development of agriculture and rural areas do not usually confer enough importance to the diversity of the farming systems at farm level (Köbrich *et al.*, 2003; Hodge and Monk, 2004; Ruiz *et al.*, 2008). The farming system at farm level is a logical consequence of the systems and holistic approaches to natural, agricultural and economic research, as well as the needs for extension services and other support activities (Kostrowicki, 1977; Dixon *et al.*, 2001; Castel *et al*., 2003). The concept of farming system is an integrated (comprehensive and multi-attribute) description of very complex agronomic, ecological and socio-economic situations both on the farm and in the farm household, made using a systems approach (Kostrowicki, 1977; Dixon *et al*., 2001; Milan *et al*., 2003; Madsen and Adriansen, 2004; Ruiz *et al.*, 2008). The performance of each farm is based on a unique farming system, so the farm typology in a given region refers to distinct types of farming system and therefore there could be good grounds for flexible accurate policy decisions to support a sustainable development paradigm as a major component of the present Common Agricultural Policy (CAP) of the European Union (EU) (Hodge and Monk, 2004; Maseda *et al.*, 2004; Nahed *et al.*, 2006; Usai *et al*., 2006; Ruiz *et al.*, 2008).

Studies in this paper focus on the evaluation of variability and typology of family farms according to farming system in a rural area of the western part of the Podlasie province (Poland) (Fig. 1), where the predominantly used conventional (high-input) or integrated agricultural systems are mostly oriented towards dairy cattle production. The rural area evaluated has a longstanding agricultural tradition, dating back to the beginning of the XV century, and has a well-consolidated farming heritage. Now its agriculture belongs to the best developed and most profitable in Poland, presenting a well-recognized example of effective dairy cattle farming, implemented in the country after the Second World War. In spite of conventional intensive agricultural systems used in the area assessed, it has maintained a typical rural landscape including traditional architecture and biodiversity which has not been changed substantially by years of modernization processes in the agricultural sector. Milk production is one of the stronger branches of Polish agriculture, of great economic and social importance (Baum and Wielicki, 2005). The Podlasie province is the most representative of intensive dairy farming in family farms around Poland. Hence, whilst the Podlasie province produces 4.0%, 2.9% and 6.1% of pigs, chickens and cereals of Poland respectively, the percentage of cows is much higher (16.4%) (GUS, 2009a,b).

Poland, in general, has advantages in milk production when compared with the big producers of the EU: the workforce is cheaper and they have efficient moderately dense forage systems. This country is closer than most EU countries to the intentions of EU-CAP reform, namely to change from a production-oriented market to a market where crop choice is linked to added value and grassland has the opportunity to regain importance. Effectively, until now, the general trend of dairy farming in the EU has been moving towards larger units, labour-saving technology and high efficiency in order to reduce costs and consequently reduce the area of grassland and the use of grazing (Kristensen *et al*., 2005). The Podlasie province is specially adapted to milk production because many farms have improved using EU support and marketing and transformation enterprises are very dynamic (IE, 2007a; Fedak, 2008). Since Poland joined the EU in 2004, milk prices have increased substantially (IERiGŻ, 2007, 2009). Recently, prices have seen a important fall from 2008 to 2009 in the EU and worldwide, of approximately 25%, the average price in Poland in 2009 being about €23/100 kg of milk whilst the EU average was about €26/100 kg (EU-DGARD, 2009b).

A considerable increase in farm size has taken place in recent years in the Podlasie province. The current size of the dairy cattle farm in the Podlasie province is still lower than the EU average, but is higher than the Polish average. Of the biggest farms of the Podlasie province (with 30 or more cows) 7.3% accounts for 30.5% of cows whereas 2.1% of the total number of farms in Poland has 19.2% of the cows (GUS, 2008, 2009a). Frequently, once the farmers have more than 30 cows, they make important changes in their production systems, put an end to cattle grazing and establish

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Abbreviations used: AA (arable areas), CAP (common agricultural policy), EU (European Union), LSU (livestock unit), PCA (principal component analysis), SA (studied area), SWOT (strength-weaknesses-opportunities-threats analysis), UAA (utilised agricultural areas).

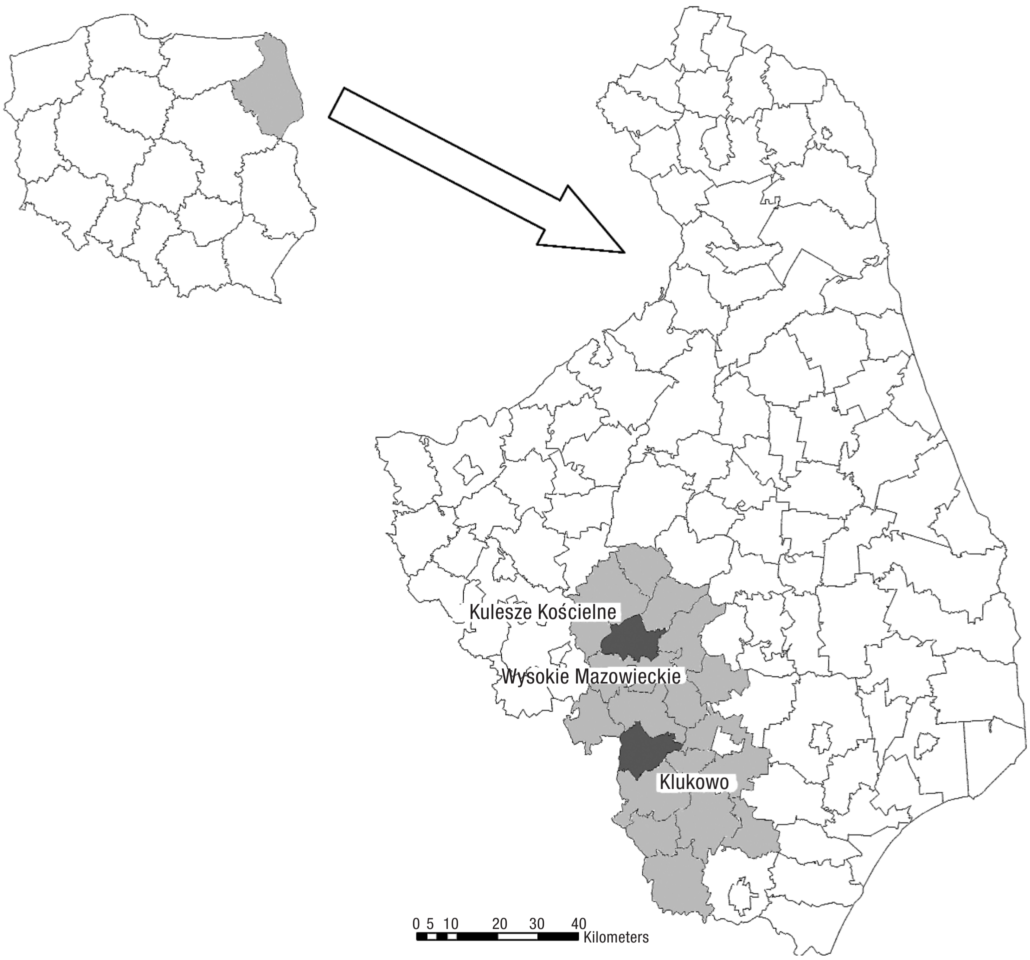

Figure 1. Location of the studied area within Poland and the Podlasie province.

a free housing system. They also improve facilities, especially in the milking section and increase grass and corn silage (IE, 2007a).

Although farms in the studied area (SA) are generally oriented towards agricultural activity, mainly within dairy farming, their farming systems are substantially differentiated. Until now only a scarce number of formal studies had been conducted among family dairy farms of the farming systems and their typology at farm level in the Podlasie province and around Poland. The most important study in this subject was carried out by Kamieniecki *et al*. (1999), who studied dairy farm systems in Central-East Poland. Therefore, we would like to present this paper as a case study in the Podlasie province, which is also more representative of other similar rural areas in the country, in order to establish a farm typology according to the farming systems in the SA and to characterise the types of system identified.

Methodology

Study sample

A survey based on interviews with owners of 123 family farms was conducted in two communes: Klukowo and Kulesze Kościelne (shown in dark grey in Fig. 1) located in the western part of the Podlasie province (shown in light grey in Fig. 1). The two studied communes are included into the municipality of Wysokie Mazowieckie. The communes are assumed to be representative of the western part of the province, considered homogenous, in an area practising conventional (intensive) agriculture (Roszkowska-Mądra *et al.,* 2006). In the Klukowo commune, the proportion of utilised agricultural areas (UAA) and forests approached 85% and 9% of the total surface area, respectively; while the proportion of arable areas (AA) and permanent grasslands accounted for 81% and 18% of UAA, respectively. In the Kulesze Kościelne commune, UAA and forests were equal to 67% and 27% of the total surface area, respectively; while AA and permanent grasslands corresponded to 70% and 29% of UAA. Soils in the Klukowo commune are more fertile than in the Kulesze Kościelne commune but in general farming systems are quite similar in each. In each commune a representative sample of 62 farms was drawn using a stratification sampling method taking randomly chosen villages as strata. Two farms were randomly selected from each village to be representative of all farms in the SA. Upon revision of the interviews, one farm was rejected from the study because of some missing answers. The sample of 123 family farms was later recognised to be representative of all farms (1,615) in the two communes and of the rural area of the western part of the Podlasie province (GUS, 2002).

The survey questionnaire includes questions on many current characteristics of the farming systems. Values of all variables refer to the 2008 situation except values concerning *farmer's score of agricultural production profitability trend over the last 5 years*. These interviews were conducted between July and November 2008 in a framework of basic research studies of the Department of Experimental Design and Bioinformatics at the Faculty of Agriculture and Biology in the Warsaw University of Life Sciences. Answers to the questions posed were arranged as data collected on six sets of 39 variables including 28 quantitative and 11 categorical-qualitative variables. Concerning these categorical-qualitative variables, 7 were binary, 1 with 3 answer options and 3 with 4 answer options. For variables with 4 answer options, 4 new variables were created, one per option. The values of each one are the percentages of this option. Variables were related to: i) soil quality, ii) socio-economic conditions, iii) infrastructure, iv) structure of agricultural production, v) inputs in agricultural production, vi) production, incomes and profitability of agricultural production and vii) index of agricultural production intensity[1] (Table 1). Some explanations should be made concerning three infrastructure and equipment variables: (i) cows are housed in free stall systems or tethered; (ii) in farms, the silage can be prepared in heaps or in bales; when both methods are used, the main method of preparation is indicated; (iii) concerning grazing, there are two possibilities, cows graze from May to October or cows never graze. In general, in the SA there are no cooperatives to purchase feed. However, some farmers are members of an informal cooperative (without official agreements). On the other hand, SA farmers mainly sell milk to a very large national cooperative (about 6,000 members, Mlekovita-Wysokie Mazowieckie, http://www.mlekovita.com.pl/php_lang/index_25.php?lg=en). In general, farmers find it difficult to supply values for some variables concerning each farm activity, because most of them do not keep records. The variables are the following: input variables (fertilizer both organic and NPK and feed for animal), variables related to incomes and variables related to profitability. In order to surpass this difficulty, farmers included in the study sample were chosen a year before the study and they were asked to collect all necessary data for calculations of these variables for one year, but it was not possible to obtain values of input variables and variables related to incomes in 2008. On the contrary, it was not possible to obtain values of *farmer's score of agricultural production profitability trend over the last 5 years*. They were estimated by farmers as their general impression, experience and observation of the trend of the economic situation on their farms.

Principal component analysis

In this research there were substantially more quantitative variables than categorical variables (they are

[1] The index of agricultural production intensity of a farm, *I*, was calculated by standardizing the four observed variables, *e.g.* share of fodder crops in total arable area (X_{17}), cattle density (X_{18}), pig density (X_{19}) and rate of NPK fertilizers (X_{22}) according to the following formula (Herzog *et al.*, 2006):

$$I = \frac{\sum_{i=1}^{n} (X_i - X_{i\min}) / (X_{i\max} - X_{i\min})}{n}$$

where X_i is the observed value of the *i*-th variable in the farm, $X_{i\,min}$ is the minimum observed value of the *i*-th variable within the studied farms, $X_{i\,max}$ is the maximum observed value of the *i*-th variable within the studied farms, *n* is the number of the variables considered in the formula. Variables attributed to index *I* should be defined in such a way that their increasing values exhibit increasing value of the index and, therefore, improvement of agricultural production intensity. Index *I* shows higher value agricultural production of a farm if it is more intensive.

Table 1. Values of considered variables (mean and standard error) for farms in the whole studied area in the Podlasie province (Poland) and for each cluster

Variables	Whole Province	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
	123 farms	31 farms	17 farms	20 farms	18 farms	37 farms
A) *Soil quality*						
Proportion of the best quality soils in utilised agricultural area (%)***	18 (±2)	44^{a} (±3)	21^{b} (±4)	5^{c} (±2)	16^{b} (±2)	3^{c} (±1)
Proportion of moderate quality soils in utilised agricultural area (%)***	66 (±2)	52^{c} (±3)	57^{bc} (±5)	75^{a} (±4)	69^{b} (±4)	75^{a} (±2)
Proportion of poor quality soils in utilised agricultural area (%)***	16 (±2)	4^{b} (±1)	22^{a} (±5)	21^{a} (±4)	15^{ab} (±4)	22^{a} (±3)
B) *Socio-economic conditions*						
Age of farmer	40.1 (±0.9)	38.6 (±1.8)	38.4 (±2.8)	44.5 (±2.5)	36.7 (±2.4)	41.2 (±1.6)
Number of persons in the farm household working off-agriculture both on- and off-farm	0.4 (±0.1)	0.4 (±0.1)	0.2 (±0.1)	0.8 (±0.1)	0.2 (±0.1)	0.4 (±0.1)
Number of persons in the farm household working in farm-agriculture***	2.1 (±0.1)	2.1^{ab} (±0.2)	2.7^{a} (±0.2)	1.5^{b} (±0.2)	2.6^{a} (±0.3)	1.9^{b} (±0.1)
Number of persons per 10 ha in the farm household working in farm-agriculture***	1.2 (±0.1)	1.2^{ab} (±0.1)	1.6^{a} (±0.2)	1.6^{a} (±0.2)	0.6^{c} (±0.0)	1.0^{b} (±0.1)
Number of persons living in the farm household**	4.9 (±0.1)	5.2^{ab} (±0.3)	5.3^{a} (±0.3)	3.9^{b} (±0.5)	5.9^{a} (±0.3)	4.7^{ab} (±0.2)
Amount of professional advice and courses attended by the farmer in year 2008**	1.9 (±0.2)	1.6^{b} (±0.2)	1.9^{ab} (±0.4)	1.0^{b} (±0.3)	3.2^{a} (±0.7)	2.1^{ab} (±0.2)
Level of education of the farmer:						
— Primary (%)*	15 (±3)	10^{b} (±5)	12^{ab} (±8)	40^{a} (±11)	6^{b} (±6)	14^{ab} (±6)
— Secondary education (%)	40 (±4)	51 (±9)	24 (±11)	30 (±11)	39 (±12)	43 (±8)
— Further education (%)	35 (±4)	29 (±8)	40 (±12)	30 (±11)	44 (±12)	35 (±8)
— University education (%)	10 (±3)	10 (±5)	24 (±11)	0 (±0)	11 (±8)	8 (±5)
Future of the farm within next 5 years:						
— Land rent (%)***	14 (±3)	16^{b} (±7)	6^{b} (±6)	50^{a} (±12)	0.0^{b} (±0.0)	3^{b} (±3)
— Stabilisation (%)	29 (±4)	26 (±8)	24 (±11)	35 (±11)	22 (±10)	35 (±8)
— Succession (%)	18 (±4)	13 (±6)	18 (±10)	10 (±7)	22 (±10)	24 (±7)
— Establishment (%)**	39 (±4)	45^{a} (±9)	53^{a} (±13)	5^{b} (±5)	56^{a} (±12)	38^{ab} (±8)
Membership of a cooperative to sell milk (%) ***	94 (±2)	90^{a} (±5)	100^{a} (±0)	60^{b} (±16)	100^{a} (±0)	100^{a} (±0)
Membership of an informal cooperative to purchase feed (%)	6 (±2)	10 (±5)	0 (±0)	5 (±5)	0 (±0)	8 (±4)
C) *Infrastructure and equipment*						
Number of innovation investments in the farm over last 5 years***	1.8 (±0.3)	1.4^{bc} (±0.2)	2.8^{ab} (±0.5)	0.2^{c} (±0.1)	3.6^{a} (±0.7)	1.8^{b} (±0.3)
Manure pad in the farm (%)***	73 (±4)	77^{a} (±8)	82^{a} (±10)	10^{b} (±7)	94^{a} (±6)	89^{a} (±5)
Sludge storage tank (%)***	73 (±4)	71^{a} (±8)	100^{a} (±0)	15^{b} (±8)	89^{a} (±8)	86^{a} (±6)
Milking equipment in the farm (%):						
— Manual milking**	4 (± 2)	6^{b} (± 4)	0^{b} (± 0)	30^{a} (± 15)	0^{b} (± 0)	0^{b} (± 0)
— Portable milking machine**	29 (± 4)	33^{ab} (± 9)	18^{b} (± 8)	70^{a} (± 15)	6^{b} (± 6)	30^{b} (± 8)
— Fixed milking machine (without separate milking shed)**	58 (± 5)	58^{a} (± 9)	76^{a} (± 11)	0^{b} (± 0)	59^{a} (± 12)	65^{a} (± 8)
— Fixed milking machine (with separate milking shed)**	9 (± 3)	3^{b} (± 3)	6^{b} (± 6)	0^{b} (± 0)	35^{a} (± 12)	5^{b} (± 4)
Free stall systems (%)***	60 (± 5)	45^{b} (± 9)	88^{a} (± 8)	0^{c} (± 0)	94^{a} (± 6)	59^{ab} (± 8)

Table 1 (cont.). Values of considered variables (mean and standard error) for farms in the whole studied area in the Podlasie province (Poland) and for each cluster

Variables	Whole Province	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
	123 farms	31 farms	17 farms	20 farms	18 farms	37 farms
Baled silage (%)	83 (± 4)	81 (± 7)	94 (± 6)	60 (± 16)	94 (± 6)	81 (± 7)
Cows never graze (%)***	59 (± 5)	48^{bc} (± 9)	82^{ab} (± 10)	10^{c} (± 10)	94^{a} (± 46)	54^{ab} (± 8)
D) *Structure of agricultural production*						
Farm area (ha)***	22.3 (± 1.3)	19.5^{b} (± 1.6)	19.5^{b} (± 1.9)	10.7^{c} (± 1.3)	47.0^{a} (± 4.1)	20.1^{b} (± 1.1)
Proportion of cereals in arable areas (%)***	62 (± 2)	58^{b} (± 3)	33^{c} (± 4)	90^{a} (± 2)	57^{b} (± 5)	66^{b} (± 2)
Proportion of root crops in arable areas (%)**	5 (± 1)	5^{ab} (± 2)	0^{b} (± 0)	8^{a} (± 2)	2^{ab} (± 1)	6^{ab} (± 1)
Proportion of fodder crops arable areas (%)***	32 (± 2)	35^{b} (± 3)	67^{a} (± 4)	2^{c} (± 2)	39^{b} (± 10.2)	28^{b} (± 2.9)
Number of cows per farm***	34.5 (± 2.7)	27.1^{c} (± 3.3)	51.1^{ab} (± 6.3)	3.2^{d} (± 0.9)	70.0^{a} (± 10.2)	32.6^{bc} (± 2.9)
Dairy cattle density (LSU ha^{-1} AA) + ***	1.4 (± 0.1)	1.3^{b} (± 0.1)	2.6^{a} (± 0.2)	0.3^{c} (± 0.1)	1.5^{b} (± 0.2)	1.5^{b} (± 0.1)
Pig density (LSU ha^{-1} AA) +	0.1 (± 0.0)	0.1 (± 0.0)	0.0 (± 0.0)	0.2 (± 0.1)	0.2 (± 0.2)	0.1 (± 0.0)
Change in livestock density within 5 last years:						
— Increase (%)*	30 (± 4)	16^{ab} (± 7)	47^{a} (± 13)	10^{b} (±7)	44^{ab} (± 12)	38^{ab} (± 8)
— Maintenance (%)	19 (± 4)	16 (± 7)	24 (± 11)	10 (±7)	17 (± 12)	24 (± 7)
— Decrease (%)**	51 (± 5)	68^{ab} (± 9)	29^{b} (± 11)	80^{a} (±9)	39^{b} (± 12)	38^{b} (± 8)
E) *Inputs in agricultural production*						
Supply of organic fertilizers (ton ha^{-1} yr^{-1})***	22.6 (± 1.1)	28.4^{a} (± 2.0)	25.4^{a} (± 2.6)	7.8^{b} (± 1.7)	26.4^{a} (± 2.7)	22.5^{a} (± 1.7)
Supply of NPK fertilizers (kg ha^{-1} yr^{-1})*	228.8 (± 9.0)	247.4^{ab} (± 21.5)	235.9^{ab} (± 17.3)	187.0^{b} (± 22.2)	277.8^{a} (± 28.7)	208.8^{ab} (± 11.0)
Contribution of commercial feeds (%)***	17 (± 2)	18^{b} (± 4)	34^{a} (± 6)	3^{c} (± 1)	20^{b} (± 4)	16^{bc} (± 2)
F) *Production, incomes and profitability of agricultural production*						
Yield of cereals (ton ha^{-1})***	4.0 (± 0.1)	4.0^{bc} (± 0.1)	4.6^{a} (± 0.2)	3.6^{c} (± 0.1)	4.2^{ab} (± 0.1)	3.9^{bc} (± 0.1)
Share of sold cereals (%)	10.8 (± 2.4)	4.4^{b} (± 2.4)	0.0^{b} (± 0.0)	52.5^{a} (± 10.0)	6.4^{b} (± 2.6)	0.8^{b} (± 0.8)
Milk yield per cow (L yr^{-1})***	5898 (± 131)	5152^{bc} (± 266)	6747^{a} (± 320)	4930^{c} (± 253)	6429^{a} (± 341)	6151^{ab} (± 167)
Contribution of agricultural production to total farm household incomes (%)***	86 (± 2)	87^{a} (± 5)	94^{a} (± 2)	66^{b} (± 7)	96^{a} (± 2)	88^{a} (± 3)
Contribution of non agricultural activities to total farm household incomes (%) ***	14 (± 2)	13^{b} (± 5)	6^{b} (± 2)	34^{a} (± 7)	4^{b} (± 2)	12^{b} (± 4)
Contribution of crop production to total farm incomes (%)***	23 (± 3)	34^{b} (± 5)	2^{c} (± 1)	62^{a} (± 9)	14^{c} (± 4)	8^{c} (± 2)
Contribution of livestock production to total farm incomes (%)***	77 (± 3)	66^{b} (± 5)	98^{a} (± 1)	38^{c} (± 8)	86^{a} (± 4)	92^{a} (± 2)
Farmer's score of agricultural production profitability trend over last 5 years:						
— Decreasing (%)	35 (± 4)	35 (± 9)	35 (± 12)	50 (± 12)	39 (± 12)	24 (± 7)
— Fluctuating (%)	32 (± 4)	39 (± 9)	29 (± 11)	35 (± 11)	28 (± 11)	27 (± 7)
— Stable (%)	15 (± 3)	23 (± 8)	6 (± 6)	10 (± 7)	6 (± 6)	19 (± 7)
— Increasing (%) *	19 (± 4)	3^{b} (± 3)	29^{a} (± 11)	5^{b} (± 5)	28^{a} (± 11)	30^{a} (± 8)
G) *Index of agricultural production intensity****	1.05 (± 0.04)	1.03^{b} (± 0.06)	1.71^{a} (± 0.07)	0.40^{c} (± 0.06)	1.22^{b} (± 0.10)	0.99^{b} (± 0.04)

[a, b, c] Means with different letters on the same row are significantly different (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$). + LSU ha^{-1} AA: Livestock unit (equivalent to one adult dairy cow) per hectare of agricultural area.

mostly transformed to quantitative discrete variables) therefore, we used classical multivariate methods suitable for quantitative variables (Hair *et al*., 1998; Köbrich *et al*., 2003; Usai *et al*., 2006). In this work the factorial analysis with principal components method was used, followed by the cluster analysis. The principal components analysis (PCA) is a form of factor analysis which first looks for a linear combination of variables that extracts maximum variance from them and then identifies a second linear combination to explain the remaining variance, leading to new orthogonal (statistically uncorrelated) variables, usually called factors. The purpose of PCA is to reduce the number of variables and thus the «dimensionality» of the problem. Each principal component (PC) in PCA is such a dimension, called a factor, interpreted in the category of a subset of original variables which are mostly correlated with the principal components (Nahed *et al*., 2006). A few first principal components account for the majority of variability within units (here farms) as measured by Euclidean distance, thus they are the most important factors separating most of the units. Variables most closely correlated with these first PCs contribute most to the farm variation for the set of variables examining farming systems and therefore, they are most important in discriminating between the farms. PCA was used for the set of all variables after they were standardized by extracting means from a value of some variable for a given farm and dividing the result by the standard deviation (Mardia *et al*., 1994; Krzanowski, 2000; Madsen and Adriansen, 2004). According to Ruiz *et al*. (2008) variables selected for the PCA fulfil the following requirements: (i) to be discriminative (that is, with a high variation coefficient), (ii) to have a weak correlation between each other and (iii) to be relevant in terms of description of farming-systems. Concerning the variation coefficient of the variables, in agreement with Paz *et al.* (2003) and with Nahed *et al*. (2006), quantitative variables whose variation coefficient was over 50% were retained for the multivariate analysis. The PC variability was measured by associated eigenvalues. The first PC is associated to the higher eigenvalue. The next PCs were associated to decreasing eigenvalues. Very often, authors take values higher than 1 to select the number of principal components (Paz *et al*., 2003; Ruiz *et al*., 2009). However, some authors take values higher than 0.5 (Usai *et al*., 2006) to ensure that the main components include a greater variability, although this will make interpretation more difficult. In the current study the authors have determined that the values are greater than 1 in order to obtain more clarity in the analysis. In order to identify the initial indicators with extracted factors (components) a varimax type rotation was made, which allows original indicators to be easily located in the extracted values.

Classification of farms

In order to make a classification each author selects the more interesting variables. The criterion used depends on the type of research conducted (Riveiro-Valiño *et al*., 2009). In this study the authors have taken into account particularly the variables related to the farm size and the diversity of the farming activities and as well as workforce employed on the farm and soil quality. Many authors agree that farm size is one of most important variables for classification and use this variable when there are considerable differences between farms (Castel *et al*., 2003; Nahed *et al*., 2006; Usai *et al*., 2006; Ruiz *et al*., 2008, 2009). Diversity of farming activities include different variables used by several authors (Castel *et al*., 2003; Nahed *et al*., 2006; Usai *et al*., 2006; Gaspar *et al*., 2008). Workforce employed in the farm is also used by different authors for farms classification (Milán *et al*., 2003; Gaspar *et al*., 2008; Ruiz *et al*., 2008). Finally, in this study an important variable has been taken into account: soil quality. This variable is used less frequently than previous variables for the classification of farms, especially in regions where soils are fairly homogeneous. However, in the current study, where there are large differences in soil quality between farms, this variable has a significant influence on the types of crop grown on each farm.Using factorial scores assigned to the farms (in factorial analysis with the principal components method), a cluster analysis type *k*-average was used to make «best» typology of farms classifying them into groups (types) showing a maximum amount of variability between the groups and obtaining maximum homogeneity within particular groups (Mardia *et al.*, 1994; Krzanowski, 2000). To perform the cluster analysis, the principal components obtained in the first part of multivariate analysis were used instead of all the variables. These principal components were chosen because they represented different variables which are linked together with collinearity, which could interfere in the cluster analysis (Hair *et al*., 1998; Paz *et al*., 2003; Ruiz *et al*., 2009).

Concerning the choice of the number of clusters, the literature does not provide fixed rules. Therefore, this choice should be based on the experience and objectivity of the researcher, whose role is strengthened by this heuristic decision somehow strengthens the role of the researcher (Hair *et al*., 1998; Riveiro-Valiño *et al*., 2009). Finally, in the form of confirmation analysis, the differentiating effect of the grouping on the original indicators was observed. For this purpose the analysis of variance between distinguished groups (clusters) was used. Likewise, correlation analyses between the variables linked to soil quality, use and size of the farm have been made. For the statistical analysis SPSS v.14 (2005) software was used.

Diagnostic

In the last part of the discussion, in order to summarise and clarify the characteristics of the farm groups identified in SA, a diagnosis has been made using a Strength-Weaknesses-Opportunities-Threats analysis (SWOT). This analysis could be a basis for future works which proposes strategies to improve the viability of Polish dairy cattle systems.

Results

Principal components analysis

Quantitative variables retained for the factorial analysis because they have a variability coefficient higher than 50% are the following: *proportion of the best quality soils in UAA*, *proportion of poor quality soils in UAA, number of persons in the farm household working off-agriculture both on- and off-farm, number of persons in the farm household working in farm-agriculture, number of persons per 10 ha in the farm household working in farm-agriculture, amount of professional advice and courses attended by the farmer in year 2008, number of innovation investments in the farm over the last 5 years, farm area, proportion of root crops in arable areas, proportion of fodder crops in arable areas, number of cows, dairy cattle density, pig density, supply of organic fertilizers, contribution of commercial feeds, share of cereals sold, contribution of non agricultural activities to total farm household incomes and contribution of livestock production to total farm incomes*. After removal of unimportant variables and those correlated with other variables included in the analysis, 6 variables have remained (Table 2).

Eigenvalues of the three principal components retained for successive cluster analysis were 2.17 for the first PC, 1.56 for the second PC and 1.09 for the third PC. The relative proportion of variance was 36.2%, 26.0% and 18.2%, respectively, and explained 80.4% of the total original variance. The eigenvectors (weight) for each of the 6 variables according to the three PC are shown in Table 2. The characteristics of each component were the following:

— First component (dimension 1): «Importance of the dairy cattle production». It includes the variables *proportion of fodder crops in AA*, *dairy cattle density* and *contribution of livestock production to total farm incomes*. The higher the positive values of the ordinates, the higher the values of three variables.

— Second component (dimension 2): «Importance of the farm area and the workforce». It includes the variables *number of persons per 10 ha in the farm household working in farm-agriculture* and *farm area*. The higher the positive values of the ordinate, the higher the values of variable *farm area* and the lower the values of variable *number of persons per 10 ha in the farm household working in farm-agriculture*.

— Third component (dimension 3) «Quality of soils». It includes only the variable *proportion of the best quality soils in utilized agricultural area*.

Table 2. Eigenvectors (weights) for each of the six variables according to the three principal components (PC) retained for the subsequent cluster analysis.

	PC1	PC2	PC3
Proportion of fodder crops in arable areas	0.811*	0.047	0.309
Dairy cattle density	0.888*	0.049	0.074
Contribution of livestock production to total farm incomes	0.806*	0.111	–0.229
Number of persons per 10 ha in the farm household working in farm-agriculture	0.080	–0.902*	0.056
Farm area	0.258	0.853*	0.036
Proportion of the best quality soils in utilised agricultural area	0.050	–0.018	0.966*

* Significance $p < 0.001$.

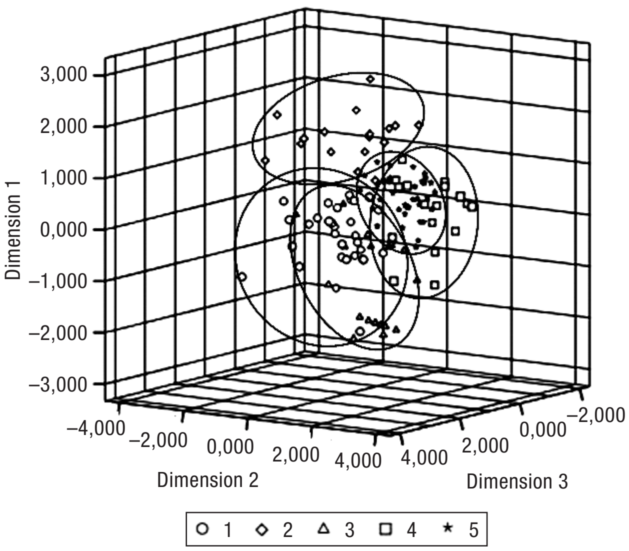

Figure 2. Distribution of farms according to three principal components. Dimension 1: higher positive values indicate more importance of the dairy cattle production. Dimension 2: higher positive values indicate more farm area and less persons working in farm-agriculture. Dimension 3: higher positive values indicate higher quality of soils.

Classification of farms and description of their groups with respect to types of farming systems

As a result of the cluster analysis type k-average, five groups with perfectly distanced centroids were obtained, which yielded interesting and common features among farms from the same group. Fig. 2 shows the distribution of farms according to the three PC. Table 1 presents descriptive statistics of the main indicators referring to the database as a whole (average results in the first column) and to each retained cluster (following columns). Only 5 variables without significant differences between groups are reported: *age of farmer*, *number of persons in the farm household working off agriculture both on- and off-farm, membership of an informal cooperative to purchase feed, baled silage* and *pig density.*

The main characteristics of five retained groups are shown in Table 3 which contains strengths and weaknesses corresponding to the SWOT analysis. To summarise the characteristics of each group in a sentence:

Table 3. Strengths and weaknesses for each farm group identified

Groups	Strengths	Weaknesses
1	High quality of soils Medium dairy cattle density	Low-medium milk production per cow Low-medium technology Low increase of profitability
2	High milk production per cow Medium-high technology High increase of profitability in 5 last years High proportion of fodder crops	High dairy cattle density High intensification High contribution of commercial feeds Low diversification High number of workers per 10 ha
3	The higher contribution of non agricultural incomes in studied area	Low quality of soils Low proportion of fodder crops Low farm size Low milk production per cow High number of workers per 10 ha Low technology Low proportion of establishment in the future
4	High farm size High technology High increase of profitability Not high dairy cattle density High milk production per cow Low number of workers per 10 ha	
5	High increase of profitability in 5 last years Medium dairy cattle density Medium-high milk production level	Low soils quality

Group 1: farms of this group have medium farm area, medium dairy cattle density, low-medium milk yield per cow and a large share of the best quality soils.

Group 2: farms of this group have medium farm area, high dairy cattle density and high milk yield per cow.

Group 3: farms of this group have low farm area, low dairy cattle density, low milk yield per cow and low technology in milking equipment.

Group 4: farms of this group have high farm area, medium dairy cattle density, high milk yield per cow and small workforce in agriculture.

Group 5: farms of this group have medium farm area, medium dairy cattle density, medium-high milk yield per cow and small share of the best quality soils.

Now, the comparison is made between different groups. Groups 1 and 5 are quite similar, except for a few variables such as soil quality (44% and 3% respectively) and milk yield per cow (5,152 and 6,151 L yr^{-1} respectively). As consequence of the higher milk yield per cow in group 5 in relation to group 1, the contribution of livestock production to total farm incomes is also higher (92% *vs* 66%) as with the percentage of farmers that have a greater tendency towards increasing agricultural production profitability over last 5 years (30% *vs* 3%). Values of these last two variables for groups 4 and 2 are similar to group 5. On the other hand, groups 2 and 4 are similar for the variable milk yield per cow (high, about 6,500 L yr^{-1}) and are rather similar in technology (high), except for the fact that in group 4 the proportion of fixed milking machines with separate milking sheds is higher than in group 2 (35% *vs* 6%) whilst the proportion without separate milking sheds is lower (59% *vs* 76%). With regard to dairy cattle density, despite farms of group 4 being the largest of the SA (47 ha and 70 cows) and farms of group 2 having a medium-sized area (about 20 ha, as in group 1), the number of cows of this latter group is rather high (51) and consequently the dairy cattle density on these farms is the higher of the SA (2.6 LSU ha^{-1} AA for group 2 and 1.4 for the whole of the SA). Group 2 also stands out because farms have a high proportion of fodder crops in AA (67%), whilst proportion of cereals in AA is the lowest of the SA (33%). Thus, the production system of group 2 is the most intensive (the index of agricultural production intensity 1.71 while the SA average is 1.05). The workforce is also high in this group. The number of persons per 10 ha in the farm household working in farm-agriculture, a variable not included in the index of agricultural production intensity equation, is higher in group 2, together with group 3 (1.6 *vs* 1.2 in the whole of SA). The worse consequence of this intensification is that in this group the contribution of commercial feeds is the highest of the SA (34% in group 2 against 17% in the SA).

Group 3 is the most different of all groups. The farm area is the lowest of the SA (11 ha). The proportion of cereals in AA is the highest of the SA (90%) and the number of cows, dairy cattle density and milk yield per cow, are the lowest of the SA (3 cows, 0.3 cows ha^{-1} and 4,930 L yr^{-1} respectively). Thus, the importance of livestock production is low and the livestock density within the last 5 years decreased in 80% of farms (the greatest decrease in the SA). This group is the only one in which the sale of grain is important (52.5%). In the other groups, farmers used almost the entire production of cereals to feed their animals. Soil quality is in general bad, similar to group 5. That, together with the lowest supply of organic fertilizers in the SA (7.8 ton ha^{-1} yr^{-1} *vs* 22.6 ton ha^{-1} yr^{-1} for the SA) and also the lowest supply of NPK fertilizers in the SA (187.0 kg ha^{-1} yr^{-1} for group 3 *vs* 228.8 kg ha^{1} yr^{-1} for the SA) leads to a low average yield of cereals, the lowest in the SA (3.6 ton ha^{-1} in group 3 *vs* 4.0 in the SA). Therefore, the farms of group 3 use relatively (in the SA) more extensive agricultural production systems, the index of agricultural production intensity being 0.4, which is the lowest of the SA. These farms are strongly into non-agricultural activities and, therefore, their proportion of non agricultural activity incomes to total farm household incomes is relatively high and in fact the highest of the SA (34% for group 3 while the average of the SA is 14%). Concerning infrastructures in farms of group 3, the number of innovation investments in the farm over the last 5 years is the lowest in the SA (0.2 in group 3 *vs* 1.8 in the SA) and the proportion of farms with manure pad on the farm and the sludge storage tank are the lowest in the SA (10% and 15% respectively for group 3 *vs* 73% and 73% in the SA). As regards milking equipment, this group is the lowest developed of SA (30% manual and 70% portable *vs* 4% and 29% respectively for the SA). Despite relatively high proportions of memberships in milk sales cooperatives in group 3, this is the lowest of SA (60% *vs* 94% for the SA). The trend to increase in agricultural production profitability over last 5 years in this group has the lowest value of the SA (only in 5% of the farms does profitability tend to increase). Furthermore, the low level of education of farmers of group 3 (40% of farmers have only primary education) leads them, in 50% of cases, to consider renting the land in the future.

Finally, the groups are compared in other variables related to farm management. The silage used mostly in the SA is baled (83%), without significant differences between groups, however the smallest proportion is in group 3 (60%). Concerning grazing of cows and the type of housing, group 4 (94%) contains the higher proportion of farms where cows never graze and use free stall systems. In group 2 proportions are also high (more than 80%) while in groups 5 and 1 the proportions are about 50% and in group 3 the proportions are very low (10% and 0% cows for the variables never graze and use free stall systems respectively).

Discussion

The mean age of the heads of farm households approached 40 years old, without significant differences between groups. The age of Polish farmers has decreased in recent years by influence of EU support for early retirement at 55 years (IE, 2007a). Farmers in the SA have an acceptable level of education (85% have more than primary school education) and a certain interest for training (1.9 professional courses in 2008). These two aspects show an accumulation of entrepreneurial human capital in this area. Farm households were generally based on strong families consisting of almost 5 persons on average and within them 2 persons on average worked on the farm in agriculture and 0.4 persons worked in non-agricultural business (including both on- and off-farm activities), demonstrating substantial variation (ranging from 0 to 2). This shows that farm diversity in non-agricultural (non-conventional) business was generally scarcely developed although this farm characteristic was considerably variable in the area. This is coherent with the findings of EU-DGARD (2009a): farm diversification is more widespread in Western and Northern Europe. The mean number of persons not employed in the farm households of SA (children or retired people) corresponded to about 2 persons. Workforce per 10 ha in SA is the same as the country average (1.4), higher than the EU average (0.6) and Czech Republic, a Eastern EU country that has a more developed dairy milk production than Poland (0.3) and lower than Romania, a Eastern EU country that has a less developed dairy milk production than Poland (1.6). Group 4 has the lowest number of persons per 10 ha of SA (0.6). This value is similar to the average of EU countries (EUROSTAT, 2008). In contrast, group 3 has the highest value (1.6) which is similar to that for Romania.

In relation to the farm area, the average for farms of the SA is much higher (22 ha) as compared to the whole of Poland (7.6 ha), Romania (3.9 ha), similar to EU average (16.1 ha) but is much lower in comparison to the to the Czech Republic average (127.7 ha) (EUROSTAT, 2007). According to van der Ploeg *et al.* (2009) some farmers of group 3, could leave agriculture and continue a rural existence through combining different activities and sources of income. Along the same lines, Tonini and Jongeneel (2009) and IE (2007a) say that the small farmer, in general, will not disappear because farmers will increase their activity in other types of production: calves, chickens or pigs, or they will work in agro-tourism.

As observed by Kamieniecki *et al.* (1999) in Central-East Poland, in the present work it was observed that the production and economic performance of farms in the Podlasie province is related to the soil quality and the proportion of fodder crops in AA. In general, the soil quality of Poland is moderate or low. In this country, the soil quality is high only in 3% of AA, while in 62% it is moderate and in 35% it is poor (IE, 2007a). In the SA these proportions were 18%, 66% and 16% respectively, indicating that despite the predominance, as in the country in general, of soils with moderate quality, the proportion of best quality soils is higher in the SA than in the whole of Poland.

Concerning agricultural activities of SA, crop diversity of the farms was less compared to the whole country: proportion of cereals, root and fodder crops in total AA corresponding to about 62%, 5% and 32%, respectively while the means in the country were about 75%, 5% and 6% respectively (GUS, 2008). According to IE (2007a), in general, the Podlasie province will probably increase the livestock and grazing intensification in forthcoming years because dairy cattle density is still moderate. Despite Kristensen *et al*. (2005) stating that changes in EU-CAP could lead to greater interest in development of grass areas, Bouwman *et al*. (2005) in reference to world figures, foresees an intensification of grass production. In SA, farms that have higher dairy cattle density should be specially careful to avoid excessive dairy cattle density (group 2).

Comparing livestock with crop production, in groups 4 and 5, the contribution of livestock production to total farm incomes is higher than in group 1, with significant differences. The reason for the difference is evident in the case of group 4 by consequence of the higher number of cows in farms of this group in relation to group 1 (70.0 *vs* 27.1). On the contrary, the number of cows in the farms of group 5 is not much higher than in group 1, but according to IE (2007a), the mentality of farmers changes when the number of cows reaches 30, and effectively cows of group 5 are more productive than in group 1 (6,429 *vs* 5,152 L cow^{-1} yr^{-1}).

With regard to number of cows per farm, the Podlasie province is quite comparable to the French region of Normandy 30 years ago (IE, 2007a) and to the Spanish region of Galicia today (IE, 2009). On the other hand, other aspects are comparable between these regions, for instance the grass availability and the variability of agrarian activities. In most EU countries the number of small farms has decreased substantially in recent years. However, there are still many small farms in numerous regions of the EU, for instance in Galicia 38% of farms still have less than 15 cows. This proportion is similar to the whole of Poland and is double that of the Podlasie province (IE, 2007a; GUS, 2008; IE, 2009). In the Eastern EU there are another 2 countries that together with Poland have important milk production, which have opposite situations: in Romania the number of cows per farm is still lower than in Poland (1.6) and in the Czech Republic is considerably higher (74.1) (EUROSTAT, 2008). Turning now to the SA, farms of groups 1 and 5 in 1999 probably had a similar number of cows per farm than those observed by Kamieniecki *et al.* (1999) in Central-East Poland, that is to say only 8 cows per farm of about 20 ha. But according to IE (2007a) and Fedak (2008) in recent years a significant number of Polish dairy cattle farms with less than 10 cows have increased herd sizes. This increase has happened in farms that worked in accordance with veterinary standards. Owners of these farms acquired an important part of quotas from the farmers who left dairy production (Baum and Wielicki, 2005; IE, 2007a). Concerning dairy cattle density, in SA it is relatively high (1.42 LSU ha^{-1} UAA) in comparison with the country (0.34 LSU ha^{-1} UAA) (GUS, 2009a) but it is lesser than in other UE countries like Spain, where is ranging between 5 and 6 according to IE (2007b). The increase of livestock density in SA has been more important in groups whose farms today have more cows (2, 4 and 5), which confirms the trend to increase livestock density of medium-high size farms of the Podlasie province (Barbin and You, 2009; Tonini and Jongeneel, 2009). However, this increase will depend on several factors: workforce availability, concentration of lands, and above all, milk prices and the milk quota market (Tonini, 2007; Bouamra-Mechemache *et al*., 2008).

Changes in dairy cattle density in the Podlasie province are accompanied by the increase in use of corn silage and by other changes in cattle farming, for instance the substitution of a tether system with a free stall system (IE, 2007a). The free stall system makes it possible to apply many favourable changes, for instance to enhance animal welfare and concerning workforce needs. Moreover, with these systems, farmers reach better milk production results (Baum and Wielicki, 2005). At the same time, substantial genetic improvement has been achieved in Poland. Nowadays, most farms in the Podlasie province with more than 10 cows inseminate them with Holstein bulls (IE, 2007a). Between 1990 and 2007, the milk yield per cow in the whole of the country went up by 35% to reach 4,000 kg, but it is still far below the EU average (about 6,000) (Szajner, 2009). Only in Bulgaria and Romania is this yield less than in Poland. However in the SA value is 5,898 L yr^{-1}, similar to the Czech Republic in 2008. In the most productive group of the SA (4) the yield is 6,429 L yr^{-1} (similar to France in 2008) (EUROSTAT, 2008). In the province of Podlasie, in general, the potential of cows for milk production is increasing due to the fact that in farms with more than 10 cows, all cows are inseminated with Holstein bulls (IE, 2007a).

Pig production has little importance in the SA (0.1 LSU ha^{-1} UAA) in comparison with the whole country (about 0.25 LSU ha^{-1} UAA). Finally, the average yield of cereals in SA is only 3.6 ton ha^{-1}, the average of the Podlasie province being 4.0 and the Poland average being 3.2 ton ha^{-1} (GUS, 2008). Other species of ruminants are not important in Poland whereas in Romania 80% of cows are in the mixed farms, with ewes or goats, particularly ewes (IE, 2007b).

Concerning technology, the groups of SA in descending order are 4, 2, 5, 1 and finally 3. Groups with higher technology have a larger share of farms with fixed milking machines and separate milking sheds, with silage made in bales, with free stall systems and finally with zero grazing systems (cows never graze). That confirms the trends of the Podlasie province farms when the number of cows increases, especially when the number of cows rises to over 30 (IE, 2007a). On the other hand, the more advanced technology in groups 4 and 2 corresponds to the higher number of investments made in innovations on the farm over the last 5 years in these groups (3.6 and 2.8 respectively) and also corresponds to a commitment to respect the future of farm within the next 5 years (56% and 53% respectively).

In the Podlasie province cooperatives to purchase supplies have rather little importance unlike the milk sales cooperatives. Almost all farmers are partners in a cooperative, with the lowest proportion of associated farmers to be found in group 3 (60%). These cooperatives play an important role in the export of milk and transformed dairy products. Surplus milk in Poland expressed in milk equivalent in 2006 was 23% and nearly half of this turnover corresponding to exports (IE, 2007a).

After a SWOT analysis in order to obtain a diagnostic of different groups of the SA farms, strengths and weaknesses of each group of SA are shown in Table 3. Also, general opportunities and threats in the SA have been considered, but pointing out where they are more suited to certain groups of farms. The opportunities are the following: (i) the environmental rules of the EU-CAP: the low livestock density present in SA (except in group 2) will allow EU support to be obtained in the environmental chapter (Bouwman *et al.*, 2005); (ii) the promotion of grazing: the application of the Health Check of the CAP reform (article 68) in the case of Poland foresees additional subsidies for grasslands for farms which have grazing animals (EU, 2008; CEU, 2009); (iii) the promotion of the diversification by the new EU-CAP (EU-DGARD, 2009a): the Podlasie province has the possibility to develop different activities, such as agro tourism and the processing of farm products; according to the EU-DGARD (2009a), diversification is more common in EU as more farm area and less livestock density has a farm, so, the probability to increase the diversification is major for farms of groups 1, 5 and over all 4; (iv) the change of the EU-CAP from a production-oriented market to a market (EU, 2008) and the disappearance of milk quotas in 2015: this policy mostly benefits the development of more competitive farms such as those in group 4; (v) the increase of the worldwide demand, especially in high-quality derived dairy products: the surplus milk in Poland expressed in milk equivalent in 2006 was 23%, but in the Podlasie province, this surplus is well marketed by the very active cooperatives of the region (IE, 2007a), nevertheless farmers could also try to produce and market directly (the mentioned diversification); (vi), the increase of the worldwide demand of organic products: Poland is the 5th country with the greatest increase in organic agriculture in recent years (Yussefi and Willer, 2007), and the important share of fodder in SA could contribute to the development of organic milk production. The threats are the following: (i) the increase of feed prices: this threat will become more serious because farmers do not normally purchase feed through a cooperative and is particularly serious for farms of group 2 which have a good level of technology and acceptable productivity but have a high dependence on external feed; (ii) the increase of milk production in the EU following the disappearance of milk quotas and also for international market liberalisation and consequently the fall of milk prices, which is the most important risk in the dairy production sector and as an example prices fell from 2008 to 2009 about 25% in the EU (EU-DGARD, 2009b); however the risk is lower for Poland in comparison to countries such as Spain, as the current milk prices are lower than the EU average (IE, 2007a, 2009); (iv) the increase of workers salaries due to probable development of the country: that could mostly affect farms with more workers and a lower level of technology.

Based on the results of the diagnosis it would be interesting to outline strategies for the improvement of production systems obtained in this study. But to draw up such strategies, first of all further studies should be conducted and technical and economic data of SA should be obtained. These data can be compared with the results obtained by other authors in Poland or other countries. Economic data should allow the calculation of the gross margin, which is used by several authors (Álvarez-López *et al.*, 2008; Gaspar *et al.*, 2008; Ruiz *et al.*, 2008) but will also be interesting to know the indicator of level of dependency with respect to external inputs that is used by other authors (Wroński *et al.*, 2007; Szajner, 2009). Both indicators are very important to study the viability of agricultural systems.

Conclusions

Results of data analysis of a sample of 123 farms located in the western region of the Podlasie province highlighted the importance of dairy production in this region. Farms have diversified activities in agricultural production and also, although to a much lesser extent, in non-agricultural activities.

After carrying out a multivariate analysis, 5 groups of farms have been obtained. They are basically differentiated by the farm dimension, the soil quality, dairy cattle density, number of workers, technology and the productivity of the cows. One group has the smallest farms of the area. In this group the share of fodder crops, dairy cattle density, contribution of livestock production to total farm incomes, technology, productivity of cows and the index of agricultural production intensity are the lowest of the area. Moreover, activity in non-agricultural activities is the higher and livestock density is generally decreasing. A second group has the highest dairy cattle density of the zone and values of mentioned variables contrast with those of the first group. Concerning the number of farmers per 10 ha, both groups have the highest value of the zone. In other words, concerning the importance of dairy production, these two groups are at opposite extremes.

A third group has the largest farms of the area. In this group the technology and the productivity of cows is similar to the group with the highest dairy cattle density, but as with dairy cattle density, the values of other variables are also lower: share of fodder crops, number of farmers per 10 ha and index of agricultural production intensity. The livestock density is as a whole stable in the group with the highest farms. To summarise, in this group, together with the group with the highest dairy cattle density, farms have the best operations in SA, but in this case the level of intensification is lower.

Finally, there are two similar groups with medium characteristics in variables linked to workforce, farm area and share of different crops, but differentiated in quality of soils, technology, milk yield per cow and contribution of livestock to total farm incomes. One of these groups has similar characteristics to the group with the highest farms but farm area and technology are lower and proportion of the best quality soils is the lowest of the area. The farms of the other group have the highest proportion of best quality soils of the area and values of contribution of livestock production to total farm incomes, technology and productivity of cows are lower than in the first group. Summarizing, both groups have medium values concerning most of the variables but in the group with the best soils of the area the agricultural production has more importance and livestock productivity is a little less important than the group with the worst soils of the area.

The result of the diagnostic of dairy cattle systems in the Podlasie province obtained from this study, carried out through SWOT analysis, shows that common weaknesses for a larger number of groups are related to small farm sizes, high number of workers, low-or medium quality of soils and low or medium levels of technology. Likewise, common strengths are related to a high share of fodder crops, low livestock density, medium diversification of agrarian activities and acceptable productivity of cows.

In order to develop strategies to improve the systems identified, external opportunities and threats for the whole area should be taken into account. Opportunities are linked to the EU-CAP evolution and to a presence of important cooperatives in the region. Threats derive from the hypothetic increase of feed prices and of quantity of produced milk in the EU. The latter could lead to a fall in milk prices.

On the other hand, improvement strategies should be established taking into account the diversity of the systems identified. Likewise, these strategies should be based on technical-economic studies of different systems including indicators of profitability but also on the level of dependency on external inputs.

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