Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 8 (2013) 378 – 386

Procedia Technology

6th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2013)

The environmental profile of dairy farms in Central Macedonia (Greece)

Zaphiris Abas[a], Athanasios Ragkos*[b], Ioannis Mitsopoulos[b], Alexandros Theodoridis[c]

[a]*Department of Agricultural Development, Democritus University of Thrace, Nea Orestiada, 58200, Greece*
[b]*Department of Animal Production, Alexander Technological Educational Institute, Thessaloniki, Greece*
[c] *Faculty of Veterinary Medicine, Aristotle University of Thessaloniki, Greece*

Abstract

Dairy farming, despite its indisputable contribution to the production of edible products consumed worldwide, more than often poses threats to the environment. The purpose of this study is to provide a typology of the dairy farms situated in Central Macedonia, Greece, based on their environmental management practices. The empirical analysis uses data from a survey of 123 dairy farms in the study area. The farms are categorized into alternative profiles, using a two-step cluster analysis; the clustering is based on the results of a Categorical Principal Component Analysis, by means of which the variables describing environmental management practices are grouped into dimensions. Then, the characteristics of farmers of each category are explored by estimating a Multinomial Logit Model. The results illustrate that when it comes to the environment, dairy farmers in Central Macedonia adopt diverse farming practices, some of which are detrimental, while others promote environmental protection and, at the same time, ensure acceptable incomes for dairy farmers.

Selection and peer-review under responsibility of The Hellenic Association for Information and Communication Technologies in Agriculture Food and Environment (HAICTA)

Keywords: Two-step cluster analysis, Multinomial logit, Dairy farming, Central Macedonia, Farm typology

1. Introduction

Dairy farming constitutes one of the most important sectors of livestock production in Greece. It contributes 19.2% to the total value of animal production in Greece, while the total gross value of the bovine (calf and beef

* Corresponding author. Tel.: +30 2310 791454; fax: +30 2310 791337.
E-mail address: ragkosagrecon@mail.com

2212-0173
Selection and peer-review under responsibility of The Hellenic Association for Information and Communication Technologies in Agriculture Food and Environment (HAICTA)
doi:10.1016/j.protcy.2013.11.050

farming) sector, including meat production, exceeds one fourth of the total gross value of animal production in the country [13]. The current situation in the sector illustrates its development throughout the years. Since 1946, a systematic effort was initiated, aiming to renew cattle populations in Greece and the establishment of an integrated breeding program. The introduction of artificial insemination and the use of animals with higher production potential and other desirable characteristics brought about a gradual displacement of local indigenous breeds, which were replaced by genetically improved crossbreeds or purebred animals of foreign breeds. Within this process, the modernization of dairy sheds, the introduction of new technologies such as machine milking and the use of corn silage, and innovations in reproduction were the main factors boosting the development of the sector.

In 2010, milk yields were multiple times higher than what they were some decades ago, which demonstrates that the animals were far more productive then than what they were in the past. In order to take advantage of these features, large investments in genetic material and infrastructure became necessary. Recent developments in the sector during the last decade included the considerable reduction of the number of farms and the concentration of cow milk production to relatively fewer farms of medium or large size, which were truly capable of undertaking such financial costs. The available data show that in 2010 there were 4,252 dairy farms in Greece (reduced by 65% compared to 2000) [7], which reared 20% less cows than 2000 (approximately 144,000 cows) [8]. However, milk production remained stable during this decade [7], approximately 680,00lt.

This change in the structure of the sector and the investments realized by dairy farmers, who chose a shift from small-scale family farming to a form of entrepreneurial livestock breeding activity, brought about a considerable improvement in the general conditions under which dairy farms operate. Farmers took advantage of the favorable policy measures in force and replaced their traditional sheds, usually situated next to the family house, with modern buildings outside the villages, whose capacity was able to sustain larger herds.

The adoption of such modern practices resulted in improved animal welfare, better hygiene conditions and higher milk yields. Nonetheless, this presentation of the current situation in the dairy sector in Greece clearly shows the main environmental issues arising from the growth of the sector. The concentration of a larger number of animals in a relatively smaller area, an imminent result of the structural changes in the sector, resulted in increased waste production, while, on the other hand, existing infrastructure in most farms was not adequate to cope with it. Excessive waste degraded the quality of surface and underground water reserves and, in some cases, polluted groundwater reserves. In addition, odors from gas emissions were also a major threat to the environment. On the other hand, extensive farms which did not follow the modernization pattern continued to manage their waste poorly, so that they started to pose environmental threats on local ecosystems.

The purpose of this study is to generate a typology of dairy farms in Central Macedonia, Greece, in terms of their waste management practices, and to investigate the characteristics of each group. In particular, the "environmental profile" of each type of dairy farms is evaluated in conjunction with their economic performance and the characteristics of the farmer/head-of-farm. The empirical analysis employs established statistical tools, including Categorical Principal Component Analysis, Two-Step Cluster Analysis and Multinomial Logit models. The results of the analysis can be linked to the general performance of the farms, as the achievement of minimum environmental standards is a prerequisite for their operation.

2. Dairy production and the environment

Ruminants and particularly cattle produce edible products which are vital to the prosperity of people around the world. Nevertheless, in numerous countries, public awareness towards the adverse effects of cattle breeding to the environment and public health is constantly increasing. During the past few years, climate change has been central to political and scientific debates worldwide. Greenhouse gas (GHG) emissions [19]., including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), constitute some of the main sources of environmental pollution [14,1], and Kyoto protocol countries are committed to reduce them.

Ruminants worldwide produce about 80 mil. ton. CH_4 annually, which stand for almost a third of CH_4 emissions attributable to human activity [2]. The Environmental Protection Agency reported a production of 1,929 bil.ton. of gastrointestinal methane emissions (expressed in CO_2 equivalent) for 2005, while methane emissions from manure of production animals were calculated to 446 mil. ton. of CO_2 equivalent [5]. According to [14], 9% of CO_2, 37% of CH_4, 65% of N_2O and 64% of ammonia emissions can be attributed to animal production; methane emissions are mainly due to the digestion of ruminants, nitrous oxide emissions come from manure and ammonia is a by-product of animal urine [9]. Other studies report that the dairy cattle farming system produces 4% of the total GHG emitted annually, of which 0.52% is CH_4. These percentages include, however, all emissions attributable to the sector, that is milk production, milk processing and meat production (fattening) [3].

As illustrated above, waste from dairy farms constitutes a major source of GHG and the management practices followed by dairy farmers determine the possibilities of reduction GHG emissions. Manure is the direct and indirect source of GHG and, as a fertilizer, it contains nitrogen, other inorganic elements and water; these three factors control the process which ultimately leads to the production of N_2O and CH_4. The volume of waste produced within the dairy farm depends on the level of intensification as well as of the density of animals inside the stable [11].

Methane emissions depend on the time of storage, the temperature and the composition of manure [21], as more than 70% of the waste of dairy farms is organic. Changes in the efficient utilization of energy from feedstuff are able to control CH_4 emissions from animals. The efficiency level depends on several factors, including animal species, feedstuff (kind, quality, quantity) and environmental conditions. Cattle produce 7 to 9 times more CH_4 than sheep and goats respectively; this production is reduced by increasing the provision of proteins and is increased when the consumption of fiber is increased [20]. Increased productivity through efficient breeding programs, advances in animal nutrition and improvements in animal welfare constitute some of the main factors which may lead to less methane emissions from animals [20,19]. Nonetheless, the demand for food of animal origin worldwide and the projected trends of meat and milk demand point to the fact that ruminants will continue to be major producers of GHG emissions in the future. Indeed, according to [1] and [5], food demand is expected to grow by 1.5% annually until 2030 and by 0.9% annually until 2050; consequently, demand for food will increase up to 186% until 2050, compared to 2000.

Manure from animal production systems accounts for an estimated 30-50% of the total N_2O emissions from agriculture [4]. N_2O emissions are influenced by climate conditions, soil types and the composition of manure, alongside with the percentage of ruminants compared to the total animal population, which bring about considerable differences among countries [21, 4].

2.1 Waste management in dairy sheds

Within the shed, waste management mainly aims at keeping the interior space clean and at protecting the exterior from odors and gases, which affect the growth of animals adversely as well as the working conditions of the staff. These objectives are achieved by:

1. The correct design, construction and function of the sewage system
2. The timely and programmed disposal of waste
3. The thorough ventilation of the shed

The choice of the optimal waste management practices depends heavily on the solid content of waste. The kind of waste in a dairy bovine stable depends on the type of the stable.

The correct storage and spreading of manure reduces the probability of odor creation and minimizes environmental pressure. The mean production of manure for a medium size dairy farm is about 60lt/cow, of which 85% is water. The produced quantity of manure depends on: the animals raised, their nutrition, their age and their productivity, as well as on environmental factors [23].

For solid and semi-solid waste, an integrated management system should predominantly focus on animal welfare, by ensuring an adequate level of hygiene throughout the facilities, on environmental protection, by minimizing air and water pollution, on constraining odors and dust and on insect and pest control. It should also provide solutions to efficient harvesting, removal and disposal of waste. The choice of the correct system should also take into account the volume of waste produced annually [18]. Solid and semi-solid waste is removed using machine scrapes and/or automatic systems. These systems do not exhibit severe problems and their performance is usually satisfactory, if they are adequate for the volume of waste produced within the stable on a daily basis. The main methods of waste disposal from dairy cow barns are briefly presented as follows:

1. Disposal with mechanical loader. This is the method most commonly used for manure disposal, mainly in open-type buildings with loose housing. The mechanical loader moves along the corridor and the front house and

scrapes the manure, which is then scattered in farmland or is stored in pits.

2. Disposal using automatic scrapers, which is suitable for more frequent removal of manure from the stable and reduces the demand for human labor; nonetheless, this system is sensitive and requires frequent maintenance.

3. Robot scraper. This system uses a robot scraper which is navigated along special rails. It is particularly efficient in cleaning the whole space used and its functioning can be programmed in advanced.

4. Flushing system. This system uses clean or purified water for cleaning the corridor and, sometimes, the waiting area in the milking parlor. The water is stored in a tank under the corridor and is sprayed under high pressure, removing manure towards the sides of the corridor [15].

Fluid and semi-fluid waste is removed by natural flow through sewers and channels, either regularly or constantly through overflow. Water is sometimes used in order to improve the flow of waste. Three types of channels are usually applicable to dairy cattle stables:

1. Narrow and deep channels, which are discharged rapidly, before gas and odors are formulated.
2. Adjustable discharge channels, which are shallow, V-, U- or Y-shaped, under grate floor. Waste remains in these channels for 4-7 days; then, one end of the channel is opened and waste is discharged away from the facilities.
3. Constant flow channels. These channels are constructed with a high lower end (15-20 cm), so as to cause overflow of fluids. The content is always kept in liquid form and a spout does not permit gas and odors to enter the facilities where the animals are kept [18,11].

2.2. Processing of waste from dairy farms

Waste from dairy farms contains basic nutrients (nitrogen, phosphorus and potassium) in high concentration, therefore it constitutes an excellent source of nutrients for agricultural crops. Solid waste (manure) has been traditionally used as fertilizer, but has been massively substituted by chemical fertilizers. Lately, the combined serious efforts of scientists and industries proclaim a more generalized use of waste from dairy farms in agriculture, mainly in the form of organic fertilizers. Nevertheless, even this type of fertilizer can be harmful to the environment, as it induces eutrophication of surface water and/or contamination of ground water reserves, if it is not used rationally [17].

The rules and legislation for reducing environmental pollution become increasingly severe. Dairy farmers seek for the optimal waste management system, which will ensure animal welfare and avert environmental degradation and pressures on water reserves, by simultaneously minimizing financial costs. Modern systems permit the use of waste for fertilization of natural vegetation or of crops, while efforts are being made towards their use in energy generation. Note that keeping basic standards in waste management and the approval of environmental conditions of operation are necessary for dairy farms in order to issue an operation license.

3. Methodological framework

The data for the empirical analysis were gathered from a sample of 123 dairy farms in Central Macedonia, Greece. The choice of this particular study area was due to the fact that almost half of the cow milk production in Greece comes from this region. According to data from [7], during 2009-2010, the sector in Central Macedonia comprised 1,539 dairy farms which produced 335,600 tons of milk; these account for 33.6% of Greek dairy farms and for 48.0% of total cow milk production in the country [7]. The sample size was determined through a random stratified sampling [10]. The survey was conducted from September 2009 to August 2010 by means of a carefully designed questionnaire, through personal interviews which took place on-farm. The sampled farms accounted for all types typically operating in the region, from small family farms to larger modern ones.

The analytical framework employs the Categorical Principal Component Analysis (CatPCA) in order to reduce the original set of variables describing milking practices into a smaller set of uncorrelated components that represent most of the information found in the original variables [22]. Using the components generated by means of the CatPCA, the sampled farms are grouped to clusters/groups with common characteristics, using the Two-Step Cluster

Analysis (TSCA). TSCA constitutes an extension of a typical cluster analysis aiming at the determination of clusters which share common characteristics based on categorical and/or continuous variables. For each cluster, the main characteristics of the farmers, as well as farm characteristics are investigated through the estimation of a Multinomial Logit (MNL) model [12], which enables a regression analysis with a categorical dependent variable.

4. Results and discussion

Table 1. Results of CatPCA - Dimensions and component loadings for variables describing waste management practices

Variables	Dimensions		Communalities
	1	2	
Frequency of manure disposal	**0.535**	0.271	0.360
Frequency of cleaning of stables	0.223	0.047	0.052
Biological cleaning	0.326	0.104	0.117
Septic tank	-0.448	**0.709**	0.704
Surface disposal tank	-0.266	**0.681**	0.535
Mechanical separators	**0.835**	0.228	0.749
Primary sedimentation tank	**0.776**	0.249	0.664
Cronbach's a	0.69	0.51	0.84
Variance accounted for (%)	31.7	22.6	47.0

Table 1 presents the results of the CatPCA. The analysis yielded two dimensions with eigenvalues 2.526 and 1.805 respectively. The a-Cronbach coefficient for the overall model is very satisfactory (0.839), as well as for dimensions 1 and 2 (0.692 and 0.510 respectively). The model explains 47.0% of the total variance. Dimension 1 can be identified by considering the high loadings of components (variables) "Mechanical separator" (0.835), "Primary sedimentation tank" (0.776) and "Frequency of manure disposal" (0.535). Hence, this Dimension can be named "Mechanical separator – Tanks" because it describes modern methods in cattle breeding waste management, which effectively contribute to the mitigation of the adverse effects of the sector on the environment. When it comes to Dimension 2, variables "Septic tank" (0.709) and "Surface disposal tank" (0.681) have the highest loadings, which actually describe conventional waste disposal practices. This dimension is, thus, named "Septic tank – Surface tank".

Table 2. Results of the TSCA – Alternative farm profiles

Clusters	Cluster size		Dimensions			
			Mechanical separator – Tanks		Septic tank – Surface tank	
	Number of observations	Percentage (%)	Mean	Standard deviation	Mean	Standard deviation
1	74	60.2	0.441	0.285	0.057	0.444
2	38	30.9	-1.289	0.606	-0.409	0.525
3	11	8.9	1.496	0.359	-2.400	0.695
Total	123	100.0	0.001	1.004	0.002	1.005

The results of the Two-Step Cluster analysis are reported in Table 2. The analysis yielded three clusters of observations. The first, which is also the largest, includes 74 dairy farms (60.2% of the total sample), the second 38 (30.9%) and the third 11 (8.9%). The clusters were formulated based on the two dimensions yielded through the CatPCA, as their influence is significant for all three clusters. Specific elements identifying the three clusters can be determined by examining the means of each dimension and their respective signs, as well as the frequency analysis of the variables comprising the two dimensions describing the main waste disposal techniques (Table 3).

Table 3. Frequency analysis of variables describing waste management practices

Variables	Cluster 1	Cluster 2	Cluster 3	Total
Dimension 1 “Mechanical separator – Tanks”				
Frequency of manure disposal				
Every 2 hours,	0	4	0	4
Every 3 hours	0	2	0	2
Every 6 hours	1	16	1	18
Once a day	46	7	1	54
Once a week	23	9	9	41
When the corridor is filled	4	0	0	4
Mechanical separators				
Yes	4	31	0	35
No	70	7	11	88
Primary sedimentation tank				
Yes	0	24	0	24
No	74	14	11	96
Dimension 2 “Septic tank – Surface tank”				
Septic tank				
None	1	0	8	9
With soil bottom	5	2	1	8
With cement bottom	68	36	2	106
Surface disposal tank				
None	11	9	11	31
With soil bottom	28	8	0	36
With cement bottom	35	21	0	56

Considering the first cluster, the means of both dimensions are low and positive, implying that the farms classified in this cluster are characterized by a variety of waste management methods. In particular, they do not use mechanical separators (94.6%) nor primary sedimentation tanks (100.0%); wastes are rather disposed in impermeable septic tanks (91.9%) and surface disposal tanks, either permeable or impermeable (85.1%); manure is temporarily gathered within the tanks and is then scattered to farmland, when weather conditions are favorable (Tables 2 and 3). Manure is cleaned once a day in most of the farms (63.0%), while in others manure is cleaned less frequently (once a week by 31.5% of farms or every time the corridor is filled with manure (5.5%)). This profile describes dairy farms which undertake established waste management methods and operate mainly based on the farmer’s experience. Hence, farms of this cluster are named “Conventional”.

Within the second cluster, the means of both dimensions are negative (Table 2). All dairy farms of this category use mechanical separators and primary sedimentation tanks, while in more than half of them (57.9%) manure is cleaned every 2-6 hours (Table 3). They are also endowed with conventional means of waste disposal, namely impermeable septic tanks (94.7%) and surface disposal tanks (76.4%). These farms can be named “Sensitive”, as they have modern and environmental-friendly waste management infrastructure.

The third cluster is mainly identified by the high and positive mean of dimension “Mechanical separator – Tanks”. The results reported in Table 3 indicate that none of the farms grouped within this cluster use such modern waste management infrastructure, while manure is only cleaned once a week by 81.8% of the farms. Furthermore, they do not use septic tanks (72.8%) or surface disposal tanks (100.0%). It is evident that the environmental protection measures undertaken by these farms are rather imperfect, so they are named "Indifferent". A closer examination of these farms reveals that they are rather extensive and/or small; animals are either kept outside most of the time or in rough barns and manure and other waste disposal is done manually.

Having identified the three clusters, the next step was to investigate their salient features, by means of a Multinomial Logit Model, where the dependent variable was comprised by three distinct outcomes (participation in one of the three clusters). After testing alternative specifications, by introducing several explanatory variables, the model which was finally estimated is presented in Table 4. The explanatory variables are "HePlan" (whether or not the farm implements a health plan), "GMCow" (the farm gross margin per cow) and "Educ" (farmer's level of literacy). The particular effects of a marginal change in each variable on the probability of participation in a certain cluster can be estimated based on their marginal effects (Table 4). The model was estimated using the maximum likelihood estimation method. Cluster 3 "Indifferent" is taken as the baseline outcome in the estimation process. McFadden R^2 is relatively low (0.14), nonetheless acceptable and the null hypothesis that all coefficients equal zero is rejected based on the LRT.

Table 4. Marginal effects of the MNL estimators

Variables	Marginal effects	Standard error	Wald-statistic
Cluster 1 "Conventional"			
Constant	-0.12644	0.17663	-0.716
HePlan	0.14567**	0.05919	2.461
Educ	0.05888	0.03720	1.583
GMCow	-0.62427*10^-04**	0.27274*10^-04	-2.289
Cluster 2 "Sensitive"			
Constant	0.16955	0.17744	0.956
HePlan	-0.15114**	0.05991	-2.523
Educ	-0.05805	0.03798	-1.528
GMCow	0.80644*10^-04***	0.27416*10^-04	2.942
Cluster 3 "Indifferent"			
Constant	-0.04311	0.05467	-0.789
HePlan	0.00547	0.01342	0.408
Educ	-0.00083	0.00778	-0.107
GMCow	-0.18217*10^-04***	0.62065*10^-05	-2.935
Log-Likelihood function		-93.377	
Likelihood Ratio Test		30,83*** (6 df)	
McFadden R2		0.14169	

The heads of farms belonging to the first cluster ("Conventional") do not follow a particular health plan consistently, as a total lack of a health plan increases the probability of participation in this cluster by 14.56%. In addition, a reduction in farm gross margin by 1€ increases the probability of participation by 0.0062%. Hence, "Conventional" dairy farmers do not achieve a high level of economic performance, as it is more probable that a farm with less gross margin participates in this cluster, while there is evidence that they are relatively highly-educated.

"Indifferent" dairy farmers also achieve relatively low economic results, as a marginal reduction in their gross margin increases the probability of participation by 0.0018%.

Contrary to the previous two categories, "Sensitive" farmers achieve the highest gross margin, as the probability of participation is increased by 0.0081% for each additional € of gross margin, and implement a health plan, as is demonstrated by the marginal result of the variable. Thus, it is illustrated that modern methods of environmental management in dairy farming constitute an important factor improving the economic performance of these farms, even without taking their positive environmental impact into account.

The probabilities of participation of a “typical” dairy farmer in Central Macedonia in each cluster are estimated to be 58.8% for “Conventional” farms, 37.8% for “Sensitive” farms and 3.4% for “Indifferent” farms. These predictions are close to the true image of the dairy sector in Central Macedonia, which reveals that the average situation is quite satisfactory, when it comes to waste management.

5. Conclusions

Waste management in Greek dairy farms constitutes one of the most pending issues, as EU legislation becomes more demanding considering the provision of licenses. Dairy farmers are, thus, obliged to comply to new standards by adopting modern techniques in waste management as well as the production of organic fertilizers and biogas.

The sampled dairy farms were clustered into three types: “Conventional”, “Sensitive” and “indifferent”. “Conventional” farmers were also depicted in the findings of [6] who report that manure was removed from the farm facilities and was gathered in piles before it was ultimately scattered in farmland, before sowing cereal crops. These farms should prioritize their adaptation to modern waste management practices and the adoption of environmental standards set out by EU legislation, in order to achieve their proper licensing but also to prove their interest towards environmental protection.

“Sensitive” farms are predominantly newly-founded and have taken the proper measures for efficient waste management (machinery for cleaning, concentrating and managing waste). [16] examined two different areas in the USA and found that a considerable number of farms follows the same practices. It should be stressed that, according to the results of the MNL model, “Sensitive” farms achieve the highest economic performance, which indicates that environmental protection is not a factor which “burdens” farms, but it rather boosts the improvement of their economic results.

“Indifferent” farms are those which do not take any measures considering waste management. Although most of them are extensive and/or rear a small number of animals, it becomes of importance that they introduce the minimum EU legislation requirements for waste management, in order to continue their operation. It should be noted that even the “Indifferent” farms, despite their environmental deficiencies, provide an alternative identity to dairy farming in Central Macedonia. Their perspective in the area should be investigated in conjunction with agricultural and rural development policies, which will contribute to their survival through their adaptation to competitive market conditions or through the establishment of communication channels with niche markets, where demand for products from such farms is higher. In this way, these farms will be able to introduce EU standards and to continue to play their formidable social and economic role, thus providing income and employment in less-favored and other rural areas.

A crucial factor for the improvement of the environmental performance of dairy farms in Central Macedonia is the provision of vocational training. The orientation of these trainings should be two-fold. At first, dairy farmers should receive adequate education considering general elements of their profession, in order to enhance their managerial skills; note that dairy farming requires expensive investments in infrastructure, therefore farmers should have at least a minimum knowledge of economics and capital management. Then, the educational activities should focus on the interconnections between dairy farming and the environment, as well as on modern technologies for efficient environmental management. In this way, dairy farmers are expected to comprehend the benefits from environmental protection.

Nonetheless, information is a necessary but not sufficient condition for the improvement of the environmental performance of the sector. Dairy producers should be convinced about the real benefits, either for them or for society as a whole, which stem from environmental-friendly management practices. For this purpose, state financial support schemes for such activities should pursue a general shift in dairy producers’ attitudes towards the environment, rather than solely the provision of financial support and technical assistance. It is commonly accepted that livestock production is endowed with an important environmental role, which is integral to its multifunctional character, and modern dairy producers should also comprehend this dimension of their profession.

Apart from education, the role of information provision is central to the improvement of the environmental performance of the sector. It is widely acknowledged that dairy farming is quite demanding when it comes to managerial skills, for which the use of state-of-the-art technology and a very good knowledge of market conditions are prerequisites. Hence, dairy farmers need to be informed about new developments in their sector in order to operate their businesses effectively; this requires the design and implementation of an integrated information campaign, which will endeavor to convince them about the entrepreneurial dimension of their profession. Such a campaign should comprise all aspects of the profession, but mainly focus on innovative technologies in monitoring, feeding, hygiene, breeding and waste management, all of which are linked to environmental protection. An integral part of such a program should include the initialization of waste management programs. The production of organic fertilizers and energy generation from waste will provide dairy farmers with additional incomes and new opportunities for alternative economic activities in rural areas, apart from the obvious benefits from the mitigation of pressures on water resources and environmental balance.

References

[1] Attwood GT, Altermanna E, Kellya WJ, Leahya SC, Zhangc L, Morrisone M. Exploring rumen methanogen genomes to identify targets for methane mitigation strategies. Animal Feed Science and Technology 2011;166:65-75.

[2] Beauchemin KA, Kreuzer M, O'Mara F, McAllister TA. Nutritional management for enteric methane abatement: a review. A.W. Australian Journal of Experimental Agriculture 2008;48(2):21–7.

[3] Bell MJ, Wall E, Simm G, Russell G. Effects of genetic line and feeding system on methane emissions from dairy systems. Animal Feed Science and Technology 2011;166:699-707.

[4] Chadwick D, Sommer S, Thorman R, Fangueiro D, Cardenas L, Amon B, Misselbrook T. Manure management: Implications for greenhouse gas emissions. Animal Feed Science and Technology 2011;166-167: 514-31.

[5] Christodoulou V, Kotsampasi V, Bambidis V. Gas emissions from livestock production. Nutritional strategies for their reduction. http://www.nagref.gr/journals/ethg/images/45/ ethg45p6-9.pdf; 2011. (In Greek)

[6] Dou Z, Knowlton KF, Zhang G, Wu Z, Kohn R. Lowering dietary P in dairy rations reduce the vulnerable P fraction in manure. Journal of Dairy Science 2001;84(1):254.

[7] Elogak (Greek Organisation for Milk and Meat). http://www.elogak.gr; 2013. (In Greek)

[8] EUROSTAT 2011. http://epp.eurostat.ec.europa.eu/portal/page/portal/ agriculture/data/matables

[9] FAO (Food and Agriculture Organization of the United Nations). Livestock's long shadow: Environmental issues and options. Rome, Italy; 2008.

[10] Farmakis N. Introduction to Sampling. A & P. Hristodoulidhi: Thessaloniki; 2002. (In Greek)

[11] Georgakakis D. Waste Management, Issue 1, Environment and waste from agriculture and industry. University notes, Athens: Agricultural University of Athens; 2010. (In Greek)

[12] Greene HW. Econometric Analysis, 6th Edition. Prentice Hall International Editions: USA; 2003.

[13] Hellenic Ministry of Rural Development and Food. Development of cattle farming in dairy and meat production. http://www.minagric.gr/greek/ ENHM_FYLADIA ZWIKHS/ENHM_FYL_zoiki.htm; 2010. (In Greek)

[14] IPCC (Intergovernmental Panel on Climate Change). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA: Cambridge University Press; 2007.

[15] Jones DL. Potential health risks associated with the persistence of Escherichia coli O157 in agricultural environments. Soil Use Manage 1999;15(2):76-83.

[16] Meyer D, Price PL, Rossow HA, Silva del Rio N, Karle PH, Robinson BM, DePeters EJ, Fadel JG. Survey of dairy housing and manure management practices in California. Journal of Dairy Science 2012; 94(9):4744-50.

[17] Newton GL, Bernard JK, Hubbard RK, Allison JR, Lowrance RR, Gascho GJ, Gates RN, Vellidis G. Managing Manure Nutrients Through Multi-crop Forage Production. Journal of Dairy Science 2003;86(6):2243-52.

[18] Nikita-Martzopoulou C. Livestock production buildings: Planning, Environment, Cow stables, Pig stables, Sheep stables, Greenhouse-type constructions. Giahoudi: Thessaloniki; 2006. (In Greek)

[19] Osada T, Takada R, Shinzato I. Potential reduction of greenhouse gas emission from swine manure by using a low-protein diet supplemented with synthetic amino acids. Animal Feed Science and Technology 2011;166-167:562-74.

[20] Shibata M, Terada F. Factors affecting methane production and mitigation in ruminants. Animal Science Journal 2010;81(1):2-10

[21] Sommer SG, Olesen JE, Petersen S, Weisbjerg MR, Rodhe LI, Béline F. Region-specific assessment of greenhouse gas mitigation with different manure management strategies in four agroecological zones. Global Change BiologyVolume 2009;15(12):2803-24.

[22] SPSS, SPSS Categories 11.5. A Software Package, Version 11.0. Chicago: SPSS Inc; 2002.

[23] Weiss WP. Factors affecting manure excretion by dairy cows. Proceedings of the 2004 Cornell Nutrition Conference, 2004; Syracuse, NY: Cornell University.