# Environmental, socio-economical and technical evaluation of a genetic enterprise from Mayabeque, Cuba, using the Statistical Model of Impact Measuring (SMIM)

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In order to evaluate the impact of indicators that influence on milk production of a genetic enterprise "Valle del Perú" from Mayabeque province, Cuba, information was gathered related to technical, economical, social and environmental indicators of five years were obtained. The analysis of main components showed that the first fourth components allowed to explain 68.38 % of the variability of this enterprise. The first component known as "Economical impact of technologies" groups 18 variables and explains 40.90 % of the variability. Impact is positive from October, 2007 to December, 2010, coinciding with the introduction of new grass species, as well as with other factors that influenced on the increase of milk production and on economical indicators. The second component is "Milk production" and it groups four variables (53.33 % of variability). A very unstable performance is determined due to the two climatic periods and a negative impact is appreciated. Causes of this behavior are argued. It can be concluded that the application of this methodology (SMIM) allowed to know the impact of the main indicators on milk production of the enterprise, demonstrating the factors of highest incidence in this process. A strategy is proposed to be followed by the enterprise for its perfecting during the next stages. This enterprise should continue working on the strategy of rehabilitation and sowing of cultured pastures, as well as applying technologies to fight the consequences of the dry period. Likewise, it is recommended to evaluate the application of this methodology in each productive unit of the enterprise, as well as include new environmental variables.

Key words: *impact index, milk production, technologies*

The last 50 years of intense development of science and technology have produced a profound transformation of the economical activity, public policies and life of people. A wide agreement in specialized literature supports this idea. However, a growing number of authors take their diagnosis a step forward. They state that the new role of science and technology in economy, politics and society have also caused important changes in the methods to obtain scientific knowledge and technological development. These changes are, not only in the ways of generating science and technology, but also in criteria of evaluation, quality standards or models of organization.

The use of different statistical tools, models and methods for evaluating impact or sustainability of systems is widely discussed within the current scientific community. Regarding the agricultural and livestock field, Bélanger *et al*. (2012) recently evaluated sustainability, through different agro-environmental indicators, in 40 husbandry farms belonging to different regions of Canada.

The Statistical Model of Impact Measuring (SMIM), developed by Torres *et al*. (2008), has been used within the agricultural and livestock field not only in Cuba (Chacón 2009, Martínez *et al*. 2010, 2012, Raez 2012 and Barreto 2012) but also at international level (Ruiz *et al*. 2012 in Mexico and Vargas *et al*. (2011) in Ecuador).

The objective of this study was to evaluate a group of productive, technical, economical, social and environmental indicators from the last 5 years (from 2006 to 2010) for determining the impact of these indicators on milk production of the genetic enterprise "Valle del Perú" from Mayabeque province, Cuba.

## Materials and Methods

The genetic enterprise "Valle del Perú", located in San José de las Lajas, Mayabeque province, limits with Jaruco municipality on the East, with the Consejo Popular Norte (San José las Lajas) on the South, with Tapaste (San José de las Lajas) on the West and with the heights of Escaleras de Jaruco on the North. The enterprise has eight entities or farms, dedicated to milk production.

A group of productive, technical, economical, social and environmental indicators from the last five years (from 2006 to 2010) were evaluated and the considered variables were 51. From them, 26 technical variables (total cows, total milk production per year, milk intake of growing calves, total sold milk, cows and heifers under the plan of artificial insemination FUIP, cows under the plan of artificial insemination, milking cows, produced liter/milking cow, births, birth rate, percentage of dead calves, deaths of adults, total area in ha, total paddocks, areas with CT-115 in ha, paddocks in area of CT-115, areas with other cultivated pastures in ha, areas with natural pastures in ha, areas with other forages in ha, area with sugarcane in ha, consumed concentrate in t, consumed minerals in t, provided forages in t, other provided feed in t, milk substitute used in t), eight economical variables (trade production cost, trade production value, gross production, gross production cost, aggregated value, utility or loss, net sales), nine social variables (average of workers, amount of labors, men, average age, workers, technicians, workers with 12th grade degree, workers with university degree, amount of trained people per year) and environmental variables (reforested areas, areas affected by fire, amount of works of maintenance and rehabilitation of lands and grasslands during the year, amount of applied fertilizers, amount of applied pesticides and use of residues as fertilizers) were evaluated. Later, an analysis of the main components was carried out in each group of variables (technical, economical, social and environmental variables) for selecting those with superior variability and use less variables in the study. The number of variables was reduced to 36.

From this gathered information, those of higher importance for evaluating impact were selected in the department of statistics from the enterprise, according to the methodology proposed by Torres *et al*. (2008). This statistical model was applied for measuring the impact of economical and productive changes obtained during the milk production process of this enterprise.

The data matrix was organized locating years and months in lines, and the 36 added variables in columns. The Statistical Model of Impact Measuring (SMIM) is a combination of multivariate methods and statistical inference allowing to determine impact indexes and to recognize positive and negative results of evaluated indicators.

The factorial punctuations were calculated for the main selected components. They are estimated through the regression method and they are guaranteed to have a zero mean and a variance equals the square of the multiple correlation among the true and estimated factorial punctuations. These factorial punctuations, obtained in each selected component, can be used as an absolute measurement of impact (positive or negative) of the most important variables in the performance of variability.

Information was gathered from precipitations occurred (2006 – 2010) in San José de las Lajas (figure 1), where the enterprise is located. Data were taken from the "Boletín Hidráulico" belonging to the Dirección de Cuencas Hidrográficas of the Servicio Hidrológico Nacional.

## Results and Discussion

Knowing the impact of technological changes allows to orient, in a safer way, the productive activity of an enterprise, territory or nation, representing a very useful element for supporting decision-making. The methodology for measuring impact is very useful for such purposes.

The correlations obtained, as a previous step to the analysis of main components, showed that 58 % of the indicators were related. The analysis of main components allowed to reduce the number of available variables from a total of 69 (42 technical, 8 social, 8 economical and 11 environmental variables) to 42, in order to determine impact with the variables with more variability. The use of different indicators allows to carry out a more integral analysis of the results.

Table 1 shows the results of the analysis of the main components, which indicated that it is possible to explain around 68.38 % of the variability with four components.

Results showed the superiority of the factors gathered in the first component, which is related to the "Economical Impact and Application of Technologies" and it will known this way. It groups 18 variables and explains 40.90 % of the variability. It groups technical, economical, social and environmental indicators.

According to the grouped variables in this component, those of the highest weight (superior to 0.71) are related to the use of cultivated pasture species of high potential (*P. purpureum*) for cut but also for grazing, economical and social variables related, in a negative way, to the milk intake for calves and the scientific degree of university

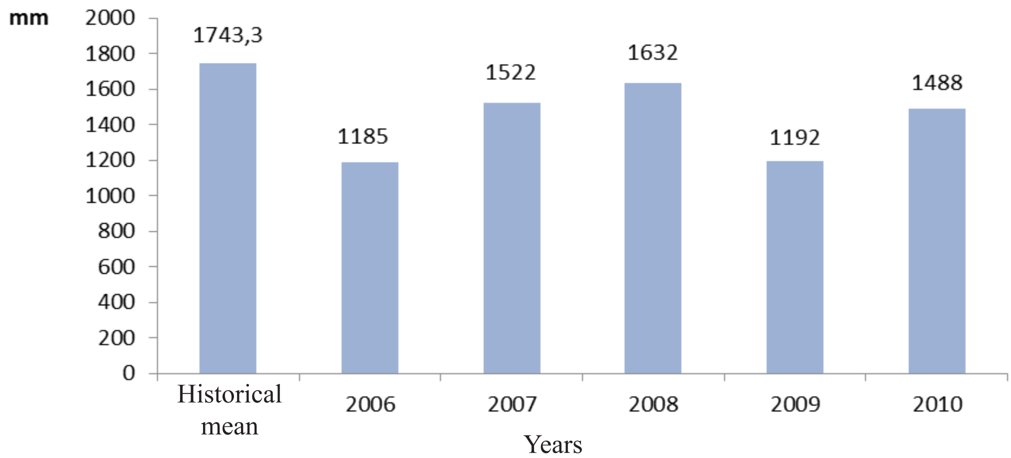


Figure1. Behavior of precipitations from 2006 to 2010 in San José de las Lajas, regarding the historical mean

Table 1. Analysis of the main components of studied indicators

| Indicators | Components | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Milk intake of calves | -0.76 | 0.07 | -0.12 | -0.10 |
| Total sold milk | 0.07 | 0.95 | 0.06 | -0.08 |
| Cows and heifers under artificial insemination plan | 0.28 | -0.15 | 0.11 | 0.81 |
| Cows under artificial insemination plan | 0.12 | -0.01 | 0.85 | 0.19 |
| Produced liters/milking cow | 0.02 | 0.96 | -0.16 | 0.04 |
| Births, % | 0.20 | -0.10 | -0.35 | -0.05 |
| Death of calves | 0.03 | -0.07 | 0.34 | -0.20 |
| Death of adults | -0.25 | -0.48 | -0.07 | -0.10 |
| Total paddocks | 0.40 | 0.14 | 0.76 | 0.25 |
| Area with CT-115, ha | 0.92 | 0.12 | 0.26 | 0.15 |
| Area with other cultivated pastures, ha | 0.87 | 0.24 | -0.04 | 0.21 |
| Supplemented forages, t | 0.71 | -0.14 | -0.01 | 0.29 |
| Amount of labors of maintenance and rehabilitation of lands and grasslands during the year | 0.81 | -0.24 | -0.25 | 0.18 |
| Use of residues as fertilizers | 0.15 | -0.29 | 0.36 | 0.19 |
| Cows/ ha | 0.25 | -0.14 | 0.13 | 0.82 |
| Total milk production per ha | 0.04 | 0.95 | 0.07 | -0.06 |
| Percentage of milking animals | 0.06 | 0.00 | 0.52 | -0.53 |
| Percentage of milking cows | -0.05 | -0.16 | -0.10 | -0.22 |
| Paddocks in the area of CT-115 | 0.92 | 0.12 | 0.26 | 0.15 |
| Percentage of area with cultivated pastures | 0.89 | 0.22 | 0.11 | 0.23 |
| Percentage sugarcane area | 0.54 | 0.35 | 0.52 | 0.38 |
| Percentage of paddocks with CT-115 | 0.85 | 0.12 | -0.39 | 0.03 |
| Percentage of reforested areas | 0.15 | 0.76 | 0.09 | -0.04 |
| Percentage of areas affected by fire | -0.36 | -0.45 | 0.19 | 0.43 |
| Commercial production, cost | 0.75 | 0.13 | 0.12 | 0.27 |
| Commercial production, value | 0.84 | 0.34 | 0.09 | 0.05 |
| Agreggated value | 0.77 | 0.17 | 0.13 | -0.15 |
| Average of workers | 0.75 | 0.06 | 0.11 | 0.02 |
| Utility or loss | 0.45 | 0.40 | -0.11 | -0.36 |
| Net sales | 0.84 | 0.36 | 0.05 | 0.08 |
| Number of workers | 0.89 | 0.03 | 0.01 | 0.02 |
| Workers | 0.91 | 0.06 | 0.13 | 0.11 |
| Technicians | 0.76 | 0.15 | 0.51 | -0.13 |
| Workers with 12th grade degree | 0.76 | 0.15 | 0.51 | -0.13 |
| University workers | -0.83 | -0.03 | 0.04 | -0.29 |
| Amount of trained people per year | 0.19 | 0.04 | -0.08 | 0.58 |
| Eigen value | 14.72 | 4.59 | 2.93 | 2.38 |
| % of explained variance | 40.90 | 12.74 | 8.14 | 6.60 |

professionals.

The economical impact of the application of these technologies is positive from October, 2007 to December, 2010, coinciding this stage with the introduction of new pasture species (*P. purpureum* cv. Cuba CT-115), as well as with other factors like an increase of paddocking, which also helped in the increase of milk production and in economical indicators.

Like in the cattle enterprise "Punta de Palma" from Pinar del Río province, there was an efficient productive, economical, environmental and social development, according to the sustainability of cattle systems of the territory, as a result of the application of new technologies and of a higher action between university and enterprise regarding technology

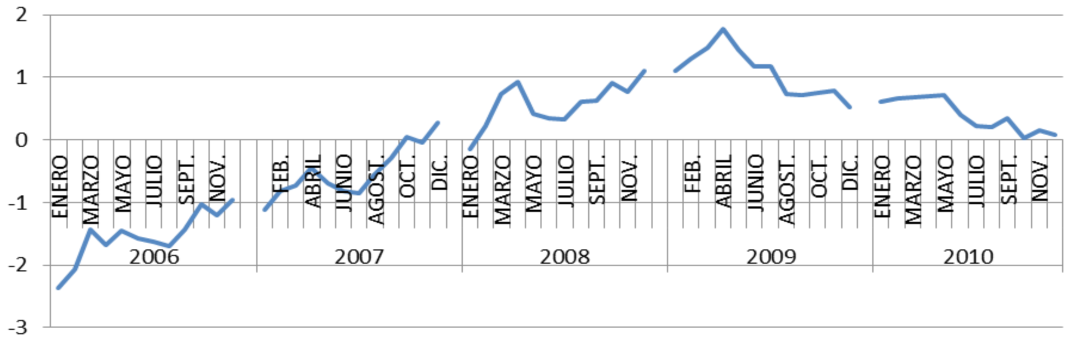


Figure 2. Index of economical impact and application of the technologies from "Valle del Perú" enterprise (2006 – 2010)

transfer (Benítez *et al*. 2012).

In the enterprise, most of the improved species introduced were grasses. However, Cuba has an important amount of information that indicates the real possibilities for milk production, according to associations of grasses with tree or creeping legumes (Ruiz *et al*., 2005). The introduction of improved species to contribute to the recovery of degraded areas helps to obtain a higher economical efficiency in cattle systems. Studies carried out by Betancourt *et al*. (2007), in farms of double purpose from El Chal, Petén, Guatemala, demonstrate this fact, because, according to these authors, losses up to 3.4 million dollars per year are estimated in animal products, due to pasture degradation in the area.

Therefore, it is important to work on the recovery of degraded areas of the enterprise, in order to obtain a higher economical efficiency. It is also necessary to analyze and assess those alternatives or options related to agricultural and livestock systems. This action should be a first order task for the enterprise because, nowadays, with the high prices of raw materials for feed and protein supplements, the use of legumes constitutes an economically viable possibility of offering feed of higher quality. Economical studies (Cino *et al*. 2004) carried out in Cuba show the possibility of using different productive alternatives for guaranteeing satisfactory levels of production, with unit costs inferior to the price per kilogram of imported milk.

In Venezuela, Urbano *et al*. (2002) demonstrated the favorable impact of introducing new grasses-tree legumes associations that allow significant increases, which were positively reflected on the economical results of exploitation. Murgueitio *et al*. (2006) show success and economical viability of multiplication and adoption of agro-forested livestock systems in Latin America. Likewise, Aldana *et al*. (2009) point out that the association of tree species can be used for fulfilling a wide range of productive, ecological and economical objectives.

According to Holmann *et al*. (2004), there is enough information about productive patterns of different animal production systems, as well as about different genetic groups. However, the information available in literature, which evaluates the economical performance according to production system and animal genotype under the same conditions, is scarce and limited. These authors studied the impact of the use of grasses from Brachiaria genre in Central America and Mexico and demonstrated the economical and technical feasibility of introducing new cultivated pastures for small and high producers. Studies of Murgueitio *et al*. (2006) show the economical contributions, plus the generated environmental services, of the grazing systems with trees developed in Central America (Costa Rica and Nicaragua) and Colombia. These authors also propose a group of considerations for determining the financial viability, which include indicators like: internal rate of return (TIR, %), present investment net value, prices, investment horizon, among others, which are considered of great importance. That is why, it is proposed, for further studies on impact evaluation of agricultural and livestock enterprises, to have previous analysis, including these evaluations for each applied technology and not considering only the economical indicators evaluated in this study.

The impact index, determined from the highest indicators obtained from the analysis of main components and previously analyzed, allow to carry out their evaluation and state the necessary strategies for achieving positive impacts in the next stages.

The second component is "Milk production" and it groups four variables and explains 53.59 % of the variability. In the rest of the components, only four variables appear with superior preponderance values, which are related to technical variables (cows/ha, number of cows under Artificial Insemination, cows and heifers under Artificial Insemination plan and total paddocks). Due to the low contribution of both components to the accumulated variance, only the impact of the first two components will be evaluated.

Some of the indicators of higher level of preponderance obtained in the analysis, coincide with those obtained by other authors (Chacón 2009, Martínez *et al*. 2010, Raez 2012 y Barreto 2012) who have evaluated production impact in different basic production units (BUP) or cattle enterprises from

Cuba. Total milk production per ha and produced liters/milking cow are among the most highlighted variables of these researches.

Similar results, according to the indicators or variables grouped in the second component, related to milk production, were obtained by Chacón (2009) in an evaluation study of economic-productive performance of dairy farms with different production systems in the enterprise El Tablón from Cienfuegos province. In this case, other variables related to production (milk per lactation, liters per cows under insemination plan, total area of the unit, areas with CT-115, number of paddocks, consumed concentrate, total production of milk per ha, feedstuff/cows under insemination plan, cost per liter, cost per produced weight and annual balance) were also studied, besides others, including economical aspects of great importance for decision-making.

In this case, indicators related to milk production (table 1) were not grouped with economic indicators of the enterprise, which are in the first component. This analysis allows to infer that, in spite of being an enterprise whose main social objective is milk production, these indicators are not contributing to its financial and economic aspects, but there are other lines in which the contribution is superior.

In Cuba, production systems of milk use pastures as basic food, and other complementary and supplementary feed (Martínez *et al*. 2006). That is why, every action for developing availability and quality of the grassland, as well as improving systems for fighting negative climate conditions, constitutes concrete aspects for any production system. In this component, the reforested areas are related to milk production indicators, which mean that environmental and productive indicators are located together.

Indicators of environmental character show the state of the environment regarding the pressure it endures. Out of the evaluated environmental indicators (reforested areas, areas affected by fire, amount of labors of maintenance and rehabilitation of lands and grasslands during the year, amount of fertilizers applied, amount of pesticides applied, areas with irrigation, use of residues as fertilizers, production of humus from worms or compost, existence of a treatment plant, percentage of reforested areas, percentage areas affected by fire) only the indicator of reforested areas had the highest preponderance and the rest of the indicators did not show great variability in the analyzed period. These indicators are very important for the sustainable development of milk production in the current agricultural and livestock systems, where food production is considered as a challenge, for a growing population, based on the preservation of natural resources.

Studies carried out by Gil *et al*. (2009) show that the use of environmental sustainability indicators allows to meet the impact of agricultural and livestock practices on an agro-ecosystem. According to these authors, the intensification of the rural sector, back then, in Villa Mercedes, Argentina, have not already impacted on the medium and there was only a movement of animal husbandry to more separated areas, or the animal concentration in lower areas, which could provoke other disturbances.

Castillo (2004) widely deals with the relation between the intensive production of milk and its environmental impact. According to this author, the research, related to the training of human resources with postgraduate formation, is a basic element of any strategy for the development of a sustainable animal husbandry. In this case, the percentage of university and technical staff of the enterprise is high; however, the amount of trained people per year is apparently not enough.

In the impact of "Milk production" (figure 3), a very variable performance, even within the years, is determined. There is a very negative impact since May, 2006, with a certain recovery in 2008, and a new relapse in 2009. In May, 2010, impact of milk production starts a very positive recovery. In the impact annual performance, differences between typical rainy and dry periods can be appreciated, which, likewise, are much related to annual climate performance. Although the climatic variables were not included in this study, there are references of other studies indicating their relation.

When analyzing the performance of precipitations (figure 1) in San José de las Lajas, Mayabeque from 2006 and 2007 and relating it with impact of milk production, it can be appreciated that 2006 and 2009 presented precipitation levels inferior to the historical means (558 and 551 mm lower, respectively), which could have influenced on these impacts. However, in 2009, apparently the effects of the dry season were less marked because the silage production was retaken at the end of 2008, and the amount of forage areas and areas with *P. purpureum* cv. Cuba CT-115 pasture was increased.

Nevertheless, it was not possible to decrease the negative impact of the season on milk production in the rest of the studied years. According to several authors (Martínez *et al*. 2010), the pasture production decreases considerably during the dry period, therefore, their optimization is needed for achieving optimal levels of meat and milk production. For this purpose, a forage balance is needed in order to know the amount of food during the dry and rainy seasons, and compare it to real needs.

Hence, the enterprise should keep devising strategies for solving food deficiencies for this period. Achieving a superior technological discipline of biomass banks constitutes an alternative for reaching a higher short-term efficiency because there is a high

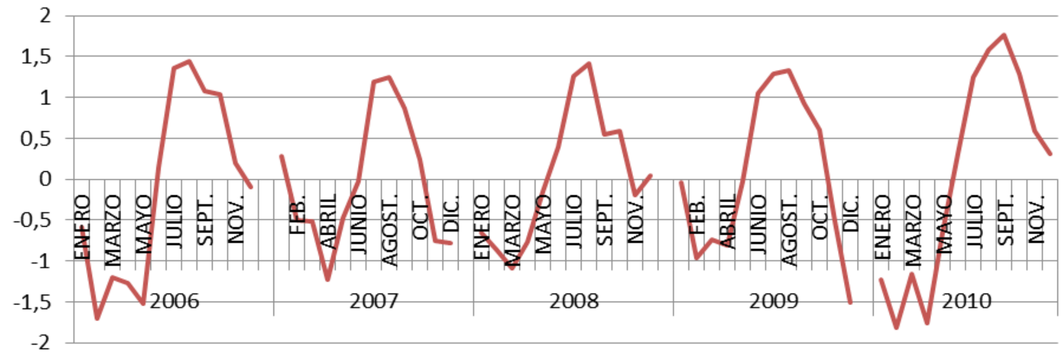


Figure 3. Impact index of milk production from "Valle del Perú" enterprise. (2006 – 2010)

percentage of areas with Cuba CT-115 pasture.

When analyzing the mean monthly performance of impact index of the "Milk production" in the enterprise (figure 4), it is appreciated that only June, July, August, September and October reach positive results.

According to studies of García-Trujillo (1983) in Cuba, in grazing systems under intensive conditions, there are milk productions per hectares that go from 5,000 kg per year in systems with grass and legumes mixtures to 20,000 kg per year in systems with fertilized grasses and high stocking rate.

of productive and economical indicators, from 2002 to 2004, in the dairy unit number 39 of the farm "Mina Blanca" from this enterprise. Milk production per ha increased from 1.263 to 2.854 L/ha/year, that means 1.591 liters more since the introduction of the technology.

Regarding the results, there are questions about the actual productivity (social, economical, productive and environmental) of the enterprise in correspondence with its potential, the adequate application level of science and technology and the fulfillment of technological discipline.

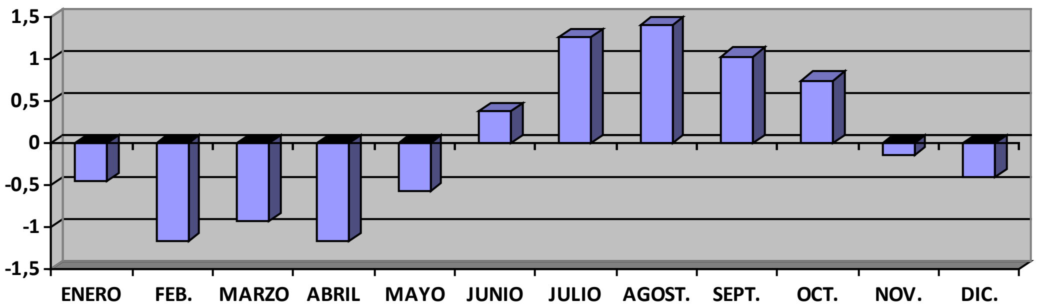


Figure 4. Monthly performance of milk production impact index of the enterprise Valle del Perú. (2006 – 2010).

The Basic Unit of Cooperative Production (UBPC, initials in Spanish) "Desembarco del Granma", Villa Clara, Cuba, doubled, in ten years, the milk production (from 60 to 1,100 L/ha/year), with the application of the biomass bank technology with Cuba CT-115 (Martínez *et al*. 2010). The mean value of the production during the analyzed period, in Valle del Perú enterprise, is 268 L/ha/year. This means that the results are inferior to those obtained by this UBPC. In spite of the increase of Cuba CT-115 sowings from 2006 to 2009, the areas varied from 920 ha to 1.700 ha, respectively. However, the incorrect application of biomass technology bank in most of the units constitutes the main cause of the obtained results.

The previously mentioned is confirmed by the results of Monteagudo (2007), who studied the effect of the introduction of biomass bank and supplementation with Norgold on the performance

However, due to the relevance of the analysis, it is necessary to continue evaluating the impact on each organization (UBPC, farms) of the enterprise with the objective of devising strategies based on the identified factors as the most important in the analysis of productivity and efficiency of the used resources.

The SMIM methodology for measuring impact of innovation or technology transfer on the agricultural and livestock field, mainly in enterprises or UBPC under milk production systems, has been used by different authors like Chacón *et al*. (2009) in the evaluation of economical-productive performance of dairy farms with different production systems in the "El Tablón" enterprise from Cienfuegos province and Martínez *et al*. (2010), who analyzed the information obtained in 10 years of work in the UBPC "Desembarco del Granma" from Santa Clara, Villa Clara province. Raez (2012) analyzed the productive impact of "Cuenca Lechera Las Tunas" Enterprise from 2003 and 2009, and Barreto (2012) analyzed the performance of milk production in UBPC Maniabo from the enterprise "Agropecuaria Municipal Las Tunas" from 1993 to 2010.

Vázquez *et al*. (2012) evaluated the socio-economical sustainability in the enterprise at the same period of time of this research. Through the use of the Mathematical-Statistical Modeling, these authors determined different socio-economical indexes per years, being 2007 the year of least index, and they observed an increase per year until 2009 and later a decrease in 2010. Similar performance was determined in the impact; therefore, the direct influence of economical variables was confirmed.

The strategy to follow by the enterprise for its development in the next stages should be the following:

• Continue working on the transformation of grassland areas in order to increase cultivated pastures, include legumes and retake silvopastoral systems.

• Apply different technologies (preservation, biomass Banks) for decreasing negative impacts of dry period.

• Establish databases at productive unit levels for evaluating impact.

• Work on sowing and renewal of forage areas and reach their highest effective life.

• Take care of technological discipline.

It can be concluded that the application of SMIM methodology and the selected indicators allowed to evaluate milk production impact from the enterprise, demonstrating the most influencing factors in this process. The enterprise, in order to improve milk production for next stages, should continue working on the strategy of rehabilitation and sowing of cultivated pastures, as well as applying technologies for fighting the negative effects of dry period. Likewise, it is recommended to evaluate milk production impact on each productive unit of the enterprise, as well as to include new environmental variables and take advantage of areas with P. purperum vc. Cuba CT-115 as biomass banks for achieving superior milk production efficiency during dry season.

## References


Aldana, P., Casanova, L. F. & Solorio, F. J. 2009.Asociación de especies arbóreas forrajeras para mejorar la productividad y el reciclaje de nutrimentos .Agricultura Técnica en México, 35: 107

Barreto, O. 2012. Evaluación de la producción de leche vacuna en la UBPC Maniabo de Las Tunas. Tesis en opción al título de Máster en Producción animal para la zona tropical. Mención Rumiantes, ICA.

Bélanger, V., Vanasse, A., Parent, D., Allard,G. & Pellerin, D. 2012. Development of agri-environmental indicators to assess dairy farm sustainability in Quebec, Eastern Canada. Ecological Indicators, Volume 23, December 2012,p.421

Benítez, M., Díaz, J. A; Ricardo, R. & Martínez, A.. 2012. Acciones en la mejora de la relación universidad Empresa para la transferencia de tecnologías agropecuarias. Estudio de caso (Universidad de Pinar del Río-Empresa Pecuaria Punta de Palma. Evento de Transferencias de tecnologías. Instituto de Ciencia Animal, Mayabeque. Cuba.

Betancourt, H., Pezo, D.A., Cruz, J & Beer, J.2007. Impacto bioeconómico de la degradación de pasturas en fincas de doble propósito en El Chal, Petén, Guatemala. Pastos y Forrajes, Vol. 30: 1.

Castillo, A. R. 2004. Impacto ambiental de los sistemas intensivos de producción de leche en los países desarrollados, problemas, soluciones y posibles escenarios futuros. Memorias VI Congreso Nacional de Control de Mastitis y Calidad de Leche. Guadalajara, México.

Chacón M.M.2009. Evaluación del comportamiento económico-productivo de lecherías con diferentes sistemas de producción en la empresa El Tablón de la Provincia de Cienfuegos. Master Thesis. ICA

Cino, D. M., Martin, P.C. & Tores, V. 2004. Preliminary economic study of alternatives. Cuban Journal of Agricultural Science: 38: 3

García-Trujillo, R. 1983. Potencial y utilización de los pastos tropicales para la producción de leche. In: Los pastos en Cuba. Tomo II, Utilización. Ed. EDICA, La Habana, Cuba. p. 248-294.

Gil, S. B., Herrero, M. A., Flores, M. C., Pachoud, M. L. & Hellmers, M. M. 2009. Intensificación agropecuaria evaluada por indicadores de sustentabilidad ambiental. Archivos de Zootecnia, vol. 58:223, pp. 413

Holmann, F., Rivas, L., Argel, P. & Pérez, E. 2004. Impacto de la adopción de pastos Brachiaria: Centroamérica y México. Available: www.ilri.org/html/PublicacionesB.htm. Consulted: October, 8th, 2012

Martínez, R. O, Aguilar P. I. & Torres, V. 2010. Análisis del impacto de la tecnología de los bancos de biomasa con el pasto Cuba CT-115 en nueve lecherías de la UBPC Desembarco del Granma, Villa Clara, Cuba. In: Resúmenes III Congreso de producción Animal. La Habana, Cuba, p. 257.

Martínez, R. O., Delgado, D., Stuar. J, Fundora. O., Michelena. J., Delgado., A, Jordán., H., Álvarez., A., Ruiz., R. & Simón., L 2006. Estrategias de alimentación para el ganado bovino en el trópico. EDICA. Instituto de Ciencia Animal. La Habana. Cuba. P.123 -134.

Martínez, R. O; Torres, V. & P. I. Aguilar. 2012. Impact of biomass banks with *Pennisetum purpureum* (Cuba CT-115) on milk production. Cuban J. Agric. Sci. 46: 249

Monteagudo, F.2007. Cambios productivos en una unidad lechera como resultado del uso del banco de biomasa con Cuba CT-115. Master Thesis.

Murgueitio, E., Cuellar, P., Ibrahim, M,. Gobbi, J., Cuartas, C.A., Naranjo, J.F., . Zapata, A, Mejía, C.E., Zuluaga, A.F. & Casasola, F. 2006. Adopción de Sistemas Agroforestales Pecuarios. Pastos y Forrajes. 29: 365

Raez, N. 2012.Caracterización e impacto de la producción de leche en la Empresa Pecuaria "Cuenca Lechera Las Tunas" en el periodo 2006-2010. Master Thesis. ICA, MES

Ruiz, M., Ruiz, J., Torres, V. & Cach, J. 2012. Study of beef meat production systems in a municipality of Hidalgo State, Mexico. Cuban J. Agric.Sci: 46: 261

Ruiz, T.E., Febles, G., Jordán, H., Castillo, E. 2005. Legumes:

their possibilities to implant sustainable cattle systems. Cuban J. Agric. Sci. Volume 39: 485

Torres, V., Ramos N., Lizazo D., Monteagudo F. & Noda A. 2008. Statistical model for measuring the impact of innovation or technology transfer in agricultura. CCuban J. Agric. Sci. 42:133

Torres, V.C., Cobo, R., C, Sánchez, L. & Raez, N. R.2013. Statistical tool for measuring the impact of milk production on the local development of a province in Cuba. Livestock Research for Rural Development, 25: 7

Urbano, D., Dávila, C., Saavedra, S., Rivas, N & Morantes, W.2002.Impacto económico sobre la producción de leche en un sistema de pastoreo con asociaciones gramíneas-leguminosas arbóreas en el Sur del Lago de Maracaibo, Venezuela. Arch. Latinoam. Prod. Anim. 2002. 10(2): 102

Vargas, J; Benítez, D; Torres Verena; Velázquez, F y Erazo, O.2011.Typification of the cattle farm in the mountain feet of Los Ríos and Cotopaxi provinces of the Republic of Ecuador. Cuban J. Agric. Sci. 45: 381

Vázquez, Y.A., Guerra, C. W. & Sánchez, O. E. 2012. Modelación Estadístico-Matemática para el estudio de la sostenibilidad socioeconómica en el sector agrícola-pecuario del municipio San José de las Lajas, provincia Mayabeque. Revista Ciencias Técnicas Agropecuarias, 20: 69

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