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Working Paper WP95-3 **April 1995**

Fourth Minnesota Padova Conference on

Food, Agriculture, and the Environment

Proceedings of a Conference Sponsored by
University of Minnesota
Center for International Food and Agricultural Policy

Universita degli Studi di Padova
Dipartimento Territorio e Sistemi Agro-forestali

Regione Veneto

Ente di Sviluppo Agricollo

SESSION V: AGRICULTURAL AND ENVIRONMENTAL HAZARDS

PAPER 6: TECHNICAL AND ECONOMIC EFFICIENCY OF FORAGE-LIVESTOCK SYSTEMS ON THE ALPS AND THEIR ENVIRONMENTAL IMPACTS: A PROPOSAL OF SOME INDEXES

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Spring Hill Conference Center, Wayzata, Minnesota
September 4-10, 1994

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TECHNICAL AND ECONOMIC EFFICIENCY OF FORAGE-LIVESTOCK SYSTEMS ON THE ALPS AND THEIR ENVIRONMENTAL IMPACTS: A PROPOSAL OF SOME INDEXES [§]

by

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[§] Paper prepared for the "Fourth Conference on Food, Agriculture, and the Environment", Spring Hill Conference Center, Minneapolis, U.S.A., September 6-8, 1994

Technical and economic efficiency of forage-livestock systems on the Alps and their environmental impacts: a proposal of some indexes[§]

1. Introduction

In the past, the Italian Alps were subject to intense agricultural and forestry exploitation. The ready availability of labour also allowed areas particularly difficult from the climatic and orographical point of view to be exploited. In contrast to what took place in the Po Valley, however, the agricultural-livestock and forestry utilisation did not cause serious environmental damage. It conferred the landscape characteristics (meadows and pastures, alternating open and closed areas etc.) which are nowadays appreciated by summer and winter visitors to the Alps. It is possible therefore to state that in the mountains agricultural utilisation of the land, at least in it's traditional forms, constitutes an important source of positive externalities. Nowadays the agricultural and livestock production techniques, or rather, the forage-livestock system, are modifying radically with heavy intensification of livestock production processes. This evolution represents the only way to defend farmers' incomes. It is carried into effect both in the increase in the number of livestock reared per farm, independently of the availability of meadows and pasturing land, and in the increase in livestock unit yields. This trend is clearly demonstrated in tables 1 and 2, where the increase verified in the last ten years in the number of livestock reared per farm and the increase in the yield level of cows functionally controlled are reported (Andrighetto et al., 1993)

d. In fact the presence of cows belonging to high milk yield breeds, such as the Holstein is rapidly increasing to the detriment of the native breeds, which are hardier but less productive.

The modifications taking place in the livestock sector have not however been accompanied by an adequate evolution, from the quantitative and especially qualitative point of view, of forage production processes. In fact the farmer has preferred to concentrate his resources on cowshed duties, or rather in that part of the production process which guarantees the best return.

[§] This paper is the result of a close co-operation between the Authors. Each Author contributed his own section of competence (Prof. I. Andrighetto, zootechnical aspects - Prof. R. Cavalli, technological aspects - Dr. P. Rosato, economic aspects - Prof. U. Ziliotto, agronomic aspects)

This has determined a reduction in the self-sufficiency in forage and, consequently, the farms turn more and more to the market for supplies, not only of concentrated feedstuff, but also of forage.

This is confirmed by a survey carried out in three producing areas of Trentino which revealed that almost all the farmers buy concentrated feedstuff, while a percentage ranging from 50 to 87% buy forage.

Another example is drawn from the results of a study conducted at Enego on the Altipiano dei Sette Comuni in the province of Vicenza (Benvenuti and Cavalli, 1993). In this area, on the technically and economically viable farms, the livestock density and yield determine a much greater need for hay than the capabilities of farm self-sufficiency. This huge feedstuff deficit is not only due to the concentration of livestock but also to the poor yield of the meadows (around 70% of potential) caused by the fact that only a single cut is carried out each year and that the conventional system of utilisation does include techniques capable of safeguarding forage quality.

The reduced utilisation of meadows and pastures involves the appearance of negative phenomena of biological and landscape degradation in the mountain environment because the agrosystem tends to modify towards a new equilibrium. This modification involves however inevitable negative consequences, such as the risk of summer fires, the instability of snow-covered slopes, soil erosion, the overpopulation of snakes, the loss of suitable breeding sites for wild animals (for example Lyrurus tetrix), the landscape becoming wild.

In substance, the intensity with which the Alps are utilised determines the necessity for a system significantly different from that which would be established under natural conditions. In fact the Alps are "inhabited" mountains where, alongside agriculture, an important and money-making summer and winter tourist business has developed which gains greatly from the aesthetic quality of the landscape, of which the land used for forage production (meadows and pastures) is a fundamental part.

The positive externalities produced by mountain agriculture are, contrary to what happens on the plain, fundamental to the other economic activities and the importance of it's contribution to local development is based on this. In this context it is necessary to avoid that agriculture weakens it's link with the area which, in the case of forage-livestock systems, is the utilisation of the farm land to produce forage for feeding the livestock. There is therefore a need to improve the technical and economic aspects of the system of livestock rearing on the mountains with the aim of identifying the critical elements and proposing

solutions which are technically feasible, economically justifiable and sustainable within the context of the environment.

With this aim, a research project to analyse the forage-livestock system in the Alps of the Veneto Region has been underway for some years. The research has included a study to define some indexes capable of demonstrating the relationships that livestock rearing and forage production establish with the technical and economic efficiency of the livestock production system. This is obviously an initial contribution, based on a limited number of observations, which requires further research, but which has already provided some useful information.

The study began with:

- the location of the different areas homogeneous in terms of livestock rearing in the Veneto Alps;
- the singling out of farms representative of these homogeneous areas;
- identification of the production systems adopted by these farms;
- definition of the indexes capable of describing the ratios between the level of the production processes and the technical and economic components of the farms analysed.

The aim is therefore to evaluate the technical and economic efficiency of the different components of the forage-livestock system to demonstrate the possibility of keeping the livestock systems strictly linked to land utilisation.

2. Materials and methods

The identification of the different areas homogeneous for livestock rearing in the Alps of the Veneto Region was carried out utilising the commune data from the Fourth General Census of Agriculture (ISTAT, 1992) and applying cluster analysis to the data of those communes where there are at least 300 cows and 30 livestock farms. In this way, 41 communes, of which 11 are in the province of Verona, 12 in that of Vicenza and 18 in that of Belluno have been selected.

To assemble the Communes into homogeneous groups, the following six variables were then used:

- percentage of farms which use tractors
- percentage of farms where the farmer spends more time away working in non-agricultural sectors

- percentage of farms with livestock
- average number of cows per farm
- percentage of utilizable agricultural surface under arable crops
- percentage of the working population engaged in agriculture

From the analysis the following areas have emerged, characterised by:

a) viable livestock rearing

b) valley floor livestock rearing

c) marginal livestock rearing

d) sporadic livestock rearing

For each area, a definite number of farms representative of the average characteristics of that area were selected.

The information gathering at the farms, carried out during 1993, was by means of an analytical survey to determine the structural, agronomic, livestock, technical, management and economic characteristics of the farm.

The data elaboration allowed the calculation of 84 descriptive variables (table 3). Indexes were subsequently defined, grouped into the following categories:

- technical-economic indexes of the livestock systems;
- technical indexes of the forage production process.

The following indexes belong to the first category:

- net milk energy of purchased feedstuff/net milk energy of total feedstuff used (IDM); the index expresses the level of the farm's dependence on the market for livestock feedstuff;
- net milk energy supplied by purchased forage/net milk energy supplied by total feedstuff used (IUS); the index expresses the utilisation level of the farm meadows and pastures and, as a consequence, the links between the farm and the land;
- total farm land area (woodland excluded)/man-work units (IE); the index expresses the potential capacity of the farm to manage the land.

The three indexes are calculated on the basis of the data from the analytical survey carried out at farm level.

The following indexes belong to the second category:

- technology used in forage production (ILM); the index expresses the technological content of the machinery ring used in forage production;

- relationship between technology and the environment (IA); the index expresses the suitability of the machinery ring used in forage production for operating in the environment, with particular reference to the slope of the fields;
- relationship between technology and forage quality (IQ); the index expresses the potential of the machinery ring to produce good quality forage;

The three indexes are defined on the basis of the evaluation of the machinery ring operating on the farm, according to a points scale.

Lastly, the weighted sum of the three indexes allows the global technological index (IT) to be obtained

$$IT = ILM + IA + 1.5\ IQ$$

The indexes were correlated against all the described variables of the farms through the application of correlation analysis and multiple regression analysis, following the stepwise procedure.

4. Results and Discussion

4.1 The livestock system

From the results of the correlation analysis (table 4) and those of the multiple regression analysis (table 5) it emerges clearly that the IDM index, defined by the net milk energy ratio of purchased feedstuff/net milk energy of total feedstuff used, is strongly linked to the economic variables. This causes the assumption that the highest net income of the farms is subordinated to the purchase of feedstuff. This interpretation is justified by the fact that only through the use of concentrated feedstuff is it possible to obtain high milk yields and therefore to amortise the fixed costs of the production system.

Regarding this, it must be stressed that the farmer, because of structural (limited farm dimensions) and environmental (limited land productivity) limitations, is unable to reduce the cost of forage production to less than the market price and is therefore inclined to optimise resource use by economies of scale in the livestock sector, reducing the unit cost of production by increasing total milk yield.

This is also confirmed by the trend of the IUS index, defined by the ratio net milk energy supplied by the purchased forage/net milk energy supplied by the total forage used. In fact, the results of the multiple regression analysis demonstrate positive correlations between the index and the productivity of the livestock system and, especially, the net income of the farm.

It can therefore be assumed that the farmer finds it expedient to purchase not only concentrated feedstuff, but also part of the necessary forage. This can be probably be connected, on the one hand, to the higher quality of the purchased forage (in general alfalfa and forage maize) compared to that of the forage produced on the farm and, on the other, to the necessity of reserving a large part of the time available for duties in the cowshed rather than for those connected to forage production. The IUS index appears to adequately define the connections between livestock duties and working the land as it reflects the alimentary requirements of the animals and the attitude of the farmer to the exploitation of the farm forage resources.

The IE index reveals, as well as a clear positive correlation with the percentage incidence of rent on the total production costs, a positive link with the number of cows reared. This demonstrates that, despite the evolution taking place, there is still a tendency to consider meadows and pastures as the natural support of the farm. Unfortunately, an obvious negative correlation exists between these and the total milk yield and the ratio total milk yield/quantity of hay consumed. In substance there is a dichotomy within the livestock section that has on one side the alimentary requirements of breeding and low productivity cows fully satisfied by the yields of mountain forage, while for high milk yield cows it is necessary to have recourse to the market. It can therefore be hypothesised that, if the aim is to increase the land used for production activities, it is necessary, other than resorting to renting, to increase the number of cows equal to the total milk yield and therefore use hardy animals with lower yield performances. In this way, systems of forage resource utilisation can be implemented, such as pastures which, reducing the farmer's duties in the cowshed, take him back onto the land, restoring the traditional function of protection and management.

4.2 The utilisation system of forage lands

The correlation analysis demonstrates the links between the IT[1] index, which represents the technology used in the forage production process, and the explanatory variables of production and farming income (table 6).

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[1] Given the method of calculating the index IT and the fact that this summarises the technology used, chiefly the significant correlations between the index and the variables are analysed. The correlations between the index IQ and the variables are also considered, taking into account the importance of the quality of the forage in the production process

However, it doesn't confirm that the technology used for forage production provides an important contribution to the formation of the income.
In fact, examination of the correlations relating to the ratio between technology and feedstuff self-sufficiency demonstrates inconsistencies.

The IT index is correlated to the quantity of feedstuff purchased and the other descriptive variables of the farm's dependence on the market for forage supplies. The IQ index, which shows fairly analogous behaviour to that of the IT index in the correlations, is positively correlated in a highly significant way only with the quantity of feedstuff purchased.

It can consequently be stated that the farms where the production system is more intensified, purchasing a large quantity of feedstuff and high-quality forage, are also equipped with the technology potentially capable of guaranteeing the production of better quality forage.

The multiple regression analysis (table 7) confirms that obtaining a high marketable gross yield requires adequate technological support aimed also at higher work productivity in the haymaking process. Furthermore, the IT index is positively correlated with the variable number of cows per man-work unit. These data confirm what was demonstrated in the livestock system, that, with a large number of cows per man-work unit, there is a clear reduction in the time that the farmer has available to work on the fields. As a consequence, he equips himself with the implements necessary to increase his work productivity and limit his time spent on forage production.

The analysis also demonstrates an apparent incongruity in the correlation between the IT index and the quantity of forage purchased. This can be explained by the assumption that improved technology doesn't anyway guarantee high-quality forage from the point of view of livestock production.

The farmer purchases machinery and equipment to render working in the field more productive, but omits the technical and managerial details which would allow a better forage quality. In fact, in every farm, the contribution of each of the three indexes which make up the IT index confirms the lack of attention paid by the farmer to the production of high-quality forage (figure 1).

5. Conclusions

On the basis of what has been demonstrated in the study it can be stated that the indexes are capable of delineating the characteristics of the forage-livestock system with sufficient precision and, especially, the relationship that this establishes with the mountain area.

In particular the technical-economic indexes linked to the livestock system IDM and IUS can adequately define the level of intensification of that system and the capability of the farmer to manage productively (thereby protecting) the mountain area.

A perfecting of the definition of forage-livestock system intensification derives from the technological indexes IT and IQ. These indexes can analyse the technology level adopted in forage production and the important contribution that this can make to farm management.

Lastly the technical-economic index IE can be used to analyse the bonds which the livestock system establishes with the mountain area in terms of land use.

From the study of the indexes, the clear need emerges to direct the development of the forage-livestock system in the Veneto Alps along different technical paths from those followed up to now. Pursuing increased profit greatly privileges improvement in the unit production of milk cows which encourages, however, feeding techniques less tied to the utilisation of local forage resources and thereby progressively reduces the capacity of land management. Re-orientation of the forage-livestock systems, however, must also take into account that milk production has been revealed as the only process capable of protecting the income of alpine farmers and that the current limitations imposed by the "milk quotas" impede any increase in production.

On the farms with adequate "milk quotas" to provide the farmer with an acceptable income (150-200 t of milk), it is necessary to increase the farm surface area, without however cutting into production costs. A proposal might be to permit free use (or even subsidised) of abandoned meadows and pastures, thereby acknowledging, also economically, the socially important role played. It should be noted that the accompanying measures of the recent CAP reform (EC Reg. 2078/92) explicitly acknowledge this role through the payment of special grants. Within this context it is necessary to adopt agronomic practices and methods of managing the technology to improve the turf and forage quality. To encourage the consumption of locally produced forage it appears to be necessary to introduce cows belonging to breeds less specialised in milk production than

those currently employed, which are hardier and capable of utilising the grass and it's derivatives (hay, silage) without any metabolic repercussions.

On farms with limited "milk quotas", either incentives are provided to sell the "milk quotas" to the more efficient farms or a stimulus to convert to the rearing of beef cattle and sheep, or animals which, reared simply for reproduction, have limited nutritional requirements and are adaptable to the mountain environment.

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Table 1 Mean stock of cows on farms which own at least ten cows located in Alpine Provinces (data referred to Communes classified as mountainous)

	1982	1992
Udine	18.7	19.8
Pordenone	20.4	17.7
Trento	18.6	23.0
Bolzano	14.1	15.1
Belluno	20.5	23.9
Vicenza	16.9	20.4
Verona	20.4	27.0
Brescia	17.6	20.5
Bergamo	15.2	17.4
Sondrio	18.5	23.2
Como	16.6	18.9
Varese	25.8	33.7
Novara	17.9	20.2
Vercelli	16.3	18.0
Torino	20.6	23.0
Aosta	17.3	20.5
Cuneo	18.9	24.0
Average of the 1355 Communes belonging to Alpine Provinces	18.5	21.5

Table 2 Milk yield and quality of cows functionally controlled (data referred to Provinces whose territory is classified as mountainous)

	Milk yield t/year per cow		Milk quality			
			fat (%)		protein (%)	
	1982	1991	1982	1991	1982	1991
Aosta	32.9	32.9	3.53	3.53	3.18	3.26
Sondrio	45.8	54.6	3.86	3.82	3.26	3.21
Trento	42.7	56.3	3.85	3.60	3.20	3.22
Bolzano	44.2	54.8	3.89	3.89	3.22	3.28
Belluno	35.5	51.6	3.84	3.78	3.15	3.19

Table 3 Variables describing the structural, livestock, technological, operational and economic components of the farm

Structural variables
Total farm land, without summer pasture land
Summer pasture and pasture farm land
Total farm land
Rented land as percentage of total farm land
Wood farm land as percentage of total farm land
Farm meadow land
Farm meadow land as percentage of total farm land
Elevation of farm land
Slope of farm land
Livestock variables
No. of cows
Livestock units
Livestock units/total farm land
Livestock units/farm meadow land
Produced amount of forage
Pastured amount of forage
Purchased amount of forage
Total amount of forage
Purchased amount of forage/total amount of forage
Purchased amount of feedstuff
Total milk yield
No. of cows/total farm land
No. of cows/farm meadow land
No. of cows/man-work units
No. of cows/farm summer pasture and pasture land
Total amount of forage (in milk feed units)/livestock units
Total amount of forage (in d.m. tons)/livestock units
Purchased amount of feedstuff/no. of cows
Total milk yield/no. of cows
Total milk yield/total farm land

Total milk yield/farm meadow land
Total milk yield/farm summer pasture and pasture land
Total milk yield/man-work units
Total milk yield/total amount of forage
Total milk yield/purchased amount of feedstuff
Produced amount of forage/farm meadow land
Produced milk feed units
Purchased amount of forage (in milk feed units)
Milk fat percentage
Milk protein percentage
Milk quality index
Purchased milk feed units/total milk feed units (feedstuff included)
Produced amount of forage/purchased amount of forage
Purchased amount of forage/purchased amount of forage (as fodder and corn silage)
Purchased amount of forage (as fodder and corn silage)/used amount of forage (as fodder and corn silage)
Produced milk feed units/total farm land
Operational variables
Time required for haymaking related to farm meadow land
Effective time/theoretical time required for haymaking
Technological variables
Farm total power
Farm total power/farm total land
Farm total power/farm meadow land
Farm total power/man-work units
Farm total power/total milk yield
Farm total power/produced amount of forage
Haymaking machinery cost per hour
Haymaking machinery cost per hectare of farm meadow land
Haymaking machinery cost per ton of hay
Capital required for purchasing a machinery ring equivalent to the farm one
Capital/farm meadow land
Capital/no. of cows
Capital/man-work units
Capital/produced amount of forage

Capital/total milk yield
Capital/gross marketable product
No. of cuts
Meadow yield at each cut
Farm meadow land/man-work units
Economic variables
Total production cost/total farm land
Total production cost/man-work units
Total production cost/no. of cows
Man-work units
Sundry charges/total production cost
Depreciation, insurance, repairs and maintenance costs/total production cost
Taxes/total production cost
Rent/total production cost
Salary/total production cost
Gross marketable production
Total production cost
Depreciation, insurance, repairs and maintenance costs
Net income
Net income/man-work units
Net income/no. of cows
Net income/farm meadow land
Net income/gross marketable production
Total farm land/man-work units
Farm meadow land/man-work units

Table 4 Correlation between the structural, livestock and economic variables and the technical and economic indexes connected to the livestock process

Structural variables	IDM	IUS	IE
Total farm land, without summer pasture land	-0.29	-0.18	0.81**
Total farm land	0.07	-0.05	0.95**
Rented land as percentage of total farm land	0.38	0.035	0.65*
Farm meadow land	0.40	0.015	0.76**
Livestock variables			
No. of cows	0.60	0.63	0.68*
Livestock units	0.82**	0.56	0.60
Livestock units/total farm land	0.77**	0.51	-0.27
No. of cows/total farm land	0.51	0.45	-0.37
Total milk yield/livestock units	0.60**	0.33	0.02
Total milk yield/no. of cows	0.79**	0.60	0.25
Total milk yield/total farm land	0.875**	0.63	-0.15
Total milk yield/purchased amount of feedstuff	0.70*	0.48	-0.37
Economic variables			
Man-work units	0.87**	0.65*	0.33
Net income/no. of cows	0.65*	0.43	0.29
Net income/gross marketable production	0.67*	0.48	0.13
Rent/total production cost	-0.78**	-0.34	0.84**
Sundry charges/total production cost	-0.68*	-0.26	0.56
Depreciation, insurance, repairs and maintenance costs/total production cost	0.78**	0.39	-0.65*
Taxes/total production cost	0.65*	-0.31	-0.57
Rent/total production cost	-0.78*	-.034	0.84**
Salary/total production cost	0.37	-0.05	0.43
Total production cost/man-work units	0.68*	0.51	0.72*
Total production cost/livestock units	0.85**	0.61	0.08

Table 5 Linkages between the structural, livestock and economic variables and the technical and economic indexes connected to the livestock process

index IDM

Positive linkage	Negative linkage	R^2
Total milk yield/no. of cows		0.94
Net income Total milk yield/man-work units		0.87
N° of cows	Total farm land Total farm land/man-work units	0.95
Gross marketable production Total production cost/total farm land Rented land as percentage of total farm land		0.96
Total farm land Total milk yield/man-work units Net income/farm meadow land		0.96
Total milk yield/total farm land Rented land as percentage of total farm land		0.89
Rented land as percentage of total farm land Net income/farm meadow land Total milk yield/man-work units		0.90
Net income/farm meadow land Total milk yield/man-work units Total farm land		0.91
Net income/man-work units Total milk yield/man-work units Total milk yield/purchased amount of feedstuff		0.86

Table 5 Continued

index IUS

Positive linkage	Negative linkage	R^2
Total milk yield Total milk yield/livestock units	Total farm land	0.85
Total production cost/total farm land		0.66
Total milk yield/total farm land Total milk yield/livestock units		0.74
N° of cows Net income/n° of cows	Total farm land	0.87
Total milk yield/n° of cows		0.60
Gross marketable production		0.58
Net income/farm meadow land Total milk yield/man-work units		0.68
Net income/man-work units Total milk yield/man-work units		0.62

index IE

Positive linkage	Negative linkage	R^2
Rent/total production cost		0.86
N° of cows	Total milk yield Total milk yield/total amount of forage	0.95

Table 6 Correlation between the structural, livestock, operational and economic variables and the technological indexes connected to forage production

Structural variables	IT	IQ
Farm meadow land	0.709**	0.623*
Livestock variables		
No. of cows	0.855***	0.721**
No. of cows/man-work units	0.881***	0.657*
Total milk yield	0.819***	0.711**
Total milk yield/man-work units	0.876***	0.712**
Total milk yield/no. of cows	0.780***	0.621*
Purchased amount of feedstuff	0.917***	0.781***
Purchased amount of feedstuff/no. of cows	0.874***	0.681**
Produced amount of forage	0.737**	0.620*
Purchased amount of forage	0.586*	0.619*
Total amount of forage	0.739**	0.662**
Operational variables		
Time required for haymaking	-0.723**	-0.408
Economic variables		
Gross marketable production	0.884***	0.771**
Total production cost	0.862***	0.678**
Total production cost/man-work units	0.862***	0.602*
Net income	0.696**	0.694**
Net income/no. of cows	0.718**	0.651*
Net income/gross marketable production	0.692**	0.578*

Table 7 Linkages between the structural, livestock and economic variables and the technological indexes connected to forage production

index IT

Positive linkage	Negative linkage	R^2
Capital Purchased amount of feedstuff		0.98
Purchased amount of feedstuff		0.84
Gross marketable production		0.88
N° of cows/man-work units Purchased amount of forage/total amount of forage		0.87
Total milk yield/man-work units Capital/man-work units Net income/n° of cows Total production cost		0.98
Purchased milk feed units/total milk feed units (feedstuff included) Net income/n° of cows Purchased amount of forage/total amount of forage		0.97
N° of cows Capital/man-work units	Effective time/theoretical time required for haymaking	0.97
Total production cost Capital/man-work units Net income/n° of cows		0.98
Total milk yield/n° of cows		0.90

Table 7 Continued

index IQ

Positive linkage	Negative linkage	R^2
Capital Purchased amount of feedstuff		0.98
Purchased amount of feedstuff		0.83
Gross marketable production		0.78
N° of cows/man-work units Purchased amount of forage/total amount of forage		0.85
Total milk yield/man-work units Capital/man-work units Net income/n° of cows Total production cost		0.98
Puchased milk feed units/total milk feed units (feedstuff included) Net income/n° of cows Purchased amount of forage/total amount of forage		0.97
N° of cows Capital/man-work units	Effective time/theoretical time required for haymaking	0.96
Total production cost Capital/man-work units Net income/n° of cows		0.98
Total milk yield/n° of cows		0.89

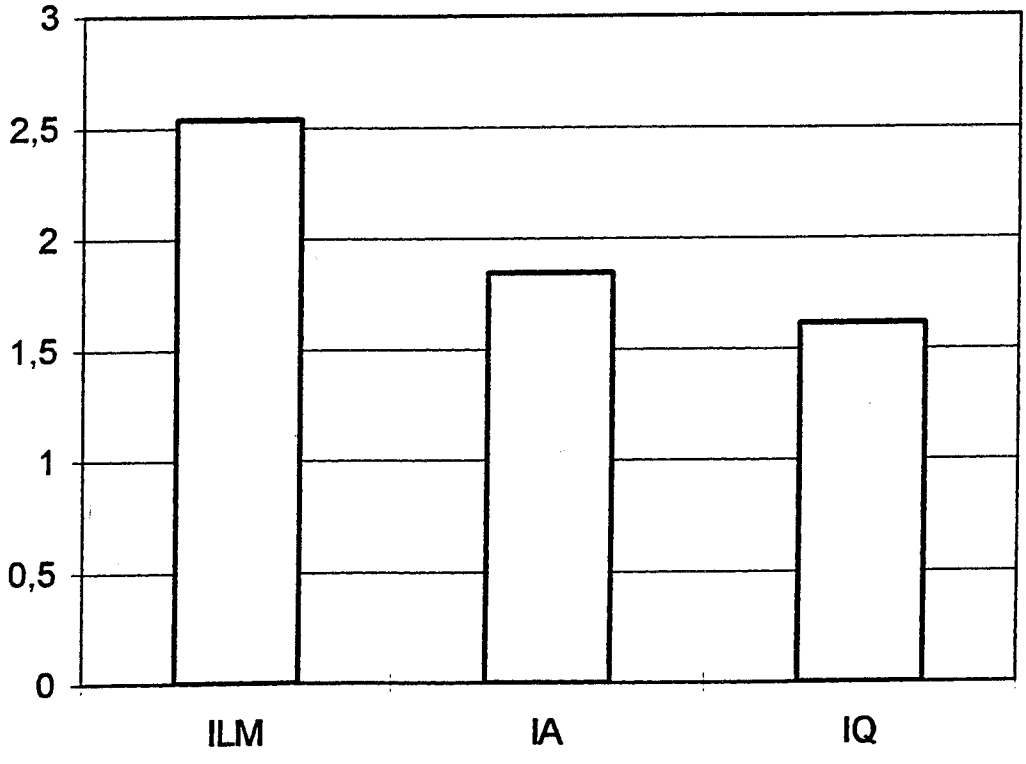

Figure 1 Description of the indexes which make up the IT index