THE MODEL OF FARM MANAGEMENT INFORMATION SYSTEM: A CASE-STUDY OF DIVERSIFIED GERMAN FARM

MODEL INFORMACIONOG SISTEMA ZA UPRAVLJANJE FARMOM: STUDIJA SLUČAJAFARME U NEMAČKOJ SADIVERZIFIKOVANOM PROIZVODNJOM

Christoph Husemann
Nebojsa Novković
Natasa Vukelić
University of Novi Sad, Faculty of Agriculture
Address: Trg Dositeja Obradovića 8
21000 Novi Sad, Serbia
Phone: +381214853392
E-mail: christoph.husemann@yahoo.de

THE MODEL OF FARM MANAGEMENT INFORMATION SYSTEM: A CASE-STUDY OF DIVERSIFIED GERMAN FARM

MODEL INFORMACIONOG SISTEMA ZA UPRAVLJANJE FARMOM: STUDIJA SLUČAJA FARME U NEMAČKOJ SA DIVERZIFIKOVANOM PROIZVODNJOM

Abstract

For more than six decades researchers, scholars and agricultural advisors have tried to implement modeling and information systems in the farming sector through out the world. Until today however, their success has been rather limited. Thereby, Germany is no exception. This is true, allthough a sophisticated farm management is more important for German farmers than ever before. The fast changing envitronment, including difficult market conditions and a high exposure to financial risks are major reasons. Farm Management Information Systems (FMIS) appear to be a powerful tool to deal with the new conditions. However, farmers still rely more on their intuition than on proper management tools, when it comes to running a farm business. The objective of this paper is to give an brief overview why modeling has not had its breakthrough in the farming sector so far. Secondly, it aims on demonstrating how a FMIS should be implemented and what farmers or agriculture advisors have to consider during its implementation. Therefore, a medium-size diversified farm in North Rhine-Westphalia (Germany) was selected as a research subject for a descriptive case-study. This approach supports a treatment of various potential problems when it comes to the implementation of a FMIS.

Keywords: Farm Management Information System, Modeling, German Farm

Abstract

Više od šest decenija širom sveta istraživači, naučnici i poljoprivredni savetodavci pokušavali su da implementiraju model informacionog sistema u poljoprivrednoj proizvodnji. Osim toga, i dan danas njihov uspeh je prilično limitiran. Nemačka, takođe, nije izuzetak. Međutim, nemački farmeri u poslednje vreme sve više shvataju značaj modela informacionog sistema za upravljanje farmom. Razlozi koji su tome doprineli su brzo nastale promene u okruženju, uključujući tu i sve težu situaciju na tržištu, kao i sve veće izlaganje finansijskim rizicima.

Model informacionog sistema za upravljanje farmom (MISF) je jedno od veoma moćnih sredstava koji mogu da se izbore sa novo nastalim uslovima. Sa druge strane, farmeri se još uvek u velikoj meri oslanjaju na sopstvenu intuiciju kada je u pitanju upravljanje farmom, umesto da koriste neki od savremenih menadžmerskih sredstava.

Cilj ovoga rada je da da pregled i objašnjenje zašto modeliranje još uvek nije našlo svoju široku primenu u poljoprivrednoj proizvodnji u meri u kojoj to zaslužuje. Rad ima za cilj da demonstrira kako bi MISF trebalo da bude implementiran i šta poljoprivredni proizvođači i/ili poljoprivredni savetodavci treba da uzmu u obzir prilikom implementacije istog. U ovoj studiji slučaja izabrana je farma srednje veličine sa diverzifikovanom proizvodnjom u Severnoj Rajni - Vestafiliji. Pristup ove studije slučaja omogućava rešavanje raznih potencijalnih problema kada je u pitanju implementacija MISF.

Ključne reči: Informacioni sistem upravljanja farmom, modeliranje, Nemačka farma

INTRODUCTION

The skillful and conceived management of farms is one of the most important success factors for their proper functioning and their sustainable development and survival in today's fast changing environment (Forster, 2002). Farm Management Information Systems

(FMIS) are a powerful tool to support farm mangers to retain their independence and to increase their profit. The models applied in FMIS can aid to deal with internal and external complexity and to achieve the optimal distribution of a farm's scarce resources to its various production processes and other activities. However, many farmer still rely more on their intuition than on management tools, when it comes to running their business(Pannell, 1996). This is true although modeling of farms has started already in the 50's and 60's of the last century. Since then, vast numbers of researchers and agricultural advisors tried to enthrall farmers for their models and to implement FMIS throughout the farming business. However, their success has been rather limited so far (McCown & Parton, 2006).

The objective of this paper is to give first a brief overview why modeling still has not had it is breakthrough in the farming sector. Secondly the paper is aiming on the development of a FMIS that depicts all production processes and their internal interconnections of a farm accurately. Furthermore, the FMIS has to allow farmers to easily access all information which are crucial for the farm's profitability.The development of a FMIS incorporates the definition of all necessary modules, their requirements/specifications and their relations among each other within the FMIS. Therefore, the accurate description of all production and other processes, their characteristics and their inter-company connections is of vital importance. Finally this paper aims on highlighting possible implementation issues of FMIS and what farmers and researchers have to consider during the implementation process.

In order to achieve the last two mentioned objectives the authorsselected as a research subject a medium size, diversified German farm located in North-Rhine Westphalia. The farm is performing classical agricultural business like cultivating land and feeding up hogs. But it additionally deals with extraordinary farm activities like pension horses, cash crop farming and direct marketing. Since it is a diversified farm it well demonstrates a complex farm structure, making it a fitting subject for the research purpose because it ideally serves as a showcase for a best practice implementation of a FMIS.

OBJECTIVES AND METHODS

The objectives and the subject of a paper define the method of research.To create a holistic understanding for the subjected matter the authors selected the form of a descriptive case-study as Gerring defines it:

[…]for methodological purposes a case study is best defined as an in-depth study of a single unit (a relatively bounded phenomenon) where the scholar's aim is to elucidate features of a larger class of similar phenomena.(Gerring, 2004, p. 341)

This form allows displaying well the implementation process and the following model testing phase of the FMIS.

The first step of theresearch project was an elaborate desk research. It had two primary scopes. The first one dealt with the question, why FMISs' pervasion performance in today's farming sector is still poor. The second scope aimed on identifying the most successful FMIS approaches currently applied. The gained insights served as the basis for the development of the FMIS model and its implantation on the analyzed farm.

The development of the FMIS model is based on a system approach, meaning, that the farm is observed as an open system, with productional, technological, economic and social subsystems. Therefore, first a system analysis of the farm has to be conducted, aiming on the identification and analysis of all the material and information flows, production processes and their interconnections. This procedure is imperative to describe the farm's production systems accurately.The procedure incorporated the data collection by conducting visual inspections (fields, animal facilities, machinery etc.), interviews with the farmer and his laborer and a thorough analysis of the farm's financial data, including balance sheets and profit and loss statements, the operating plan including spraying and fertilizing dates and crop rotation scenarios. On the basis of the collected information first a farm fact book has been completed, dealing with basic external and internal conditions.

Consequently the FMIS model has been designed, based on the system analysis and the individual information requirements of the farmer. The FMIS design comprised a listing of all production processes, focusing particularly on the internal exchange of goods. Lastly authors transferred the gained information into a marginal costing model. This approach does not take fix costs into account. Therefore all fixed assets (plant and equipment) are considered unchangeable. In other words, the model does not consider future investments or disinvestments decisions and has therefore solely a short term character.

RESULTS

For many decades scholar and agricultural advisor have applied modeling to farms (Mußhoff & Hirschauer, 2006). However, by taking German farmers in Brandenburg as an example Bokelmann et al. empirically proved that only a minority of the analyzed farmers apply modeling after it has been introduced to them(Bokelmann, Hirschauer, Nagel, &

Odening, 1996). That this situation is not a particular German issue, confirmed in their very elaborate work(McCown & Parton, 2006).

So what are the reasons for the hesitation of farmers to apply modeling to their farm? In the last 20 years scholars brought up several explanations. Figure 1 supposes to facilitate the understanding of their argumentation.

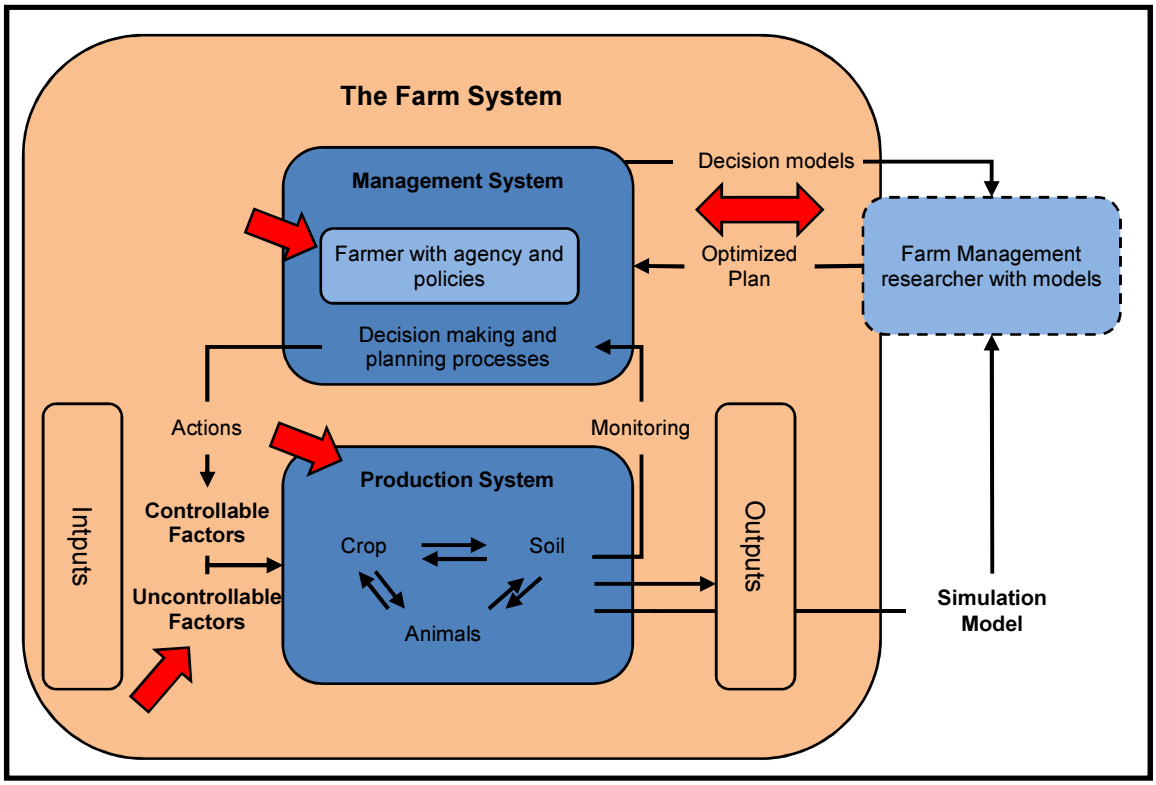

Figure 1: The Farm Systemafter(Sorensen & Kristensen, 1992)

Complexity is one of the major impediments for the application of modeling. And this complexity occurs very different ways. First, one has to acknowledge the complexity of the farms organization it-self. Various, partially very different production processes (land cultivation, husbandry etc.) have to be tuned properly. Additionally farmer deal with biological system which can never be controlled 100%. Doyle described this phenomenon as following:

"The very complexity of biological systems and their susceptibility to unplanned variations make it difficult to design adequate representations of the real world."(Doyle, 1990, p. 108)

Market risk (change of prices), financial risk and many more further increase the number of uncontrollable factors. These two sources of complexity, namely the farm and its environment lead to complex model. But complex models are expensive, difficult to understand and to use. These are unfavorable premises for an easy and swift adaptation. The

huge number of uncontrollable factors and their significant influence on the farm's profitability have another negative side effect.They create "Clouds of Vagueness" causing the perception that the success or failure of the farm is greatly exposed to chance anyway(Arrow, 1993). Consequently farmers' motivation to invest time and money in models drops dramatically. But also researchers, scholars and agricultural advisors contributed their bit. Often they do not take their counterpart, the farmer, as what he is: The major source of information and even more importantly the key factor to a successful adaptation and application of the model.

Lastly the exclusive focus only on particular production processes or activities, also called "partial-farm management" caused unsatisfying performance of the models (Malcom, 1990). The farmer does not benefit when one production process is running at its optimum when therefore others suffer and potentially eat up the just gained benefits.

Within the scope of this paper the "Whole-Farm Modeling" approach is considered most suitable to avoid the named lapses. Makeham was one of the first fostering this approach and it has been tested widely already(Makeham, 1971). For instance in Western Australia within the software MIDAS (Model of an Integrated Dryland Agricultural System)(Pannell, 1996).

When it comes to modeling a farm the firstoutcome of the farm analysis is a comprehensive "Farm Fact Book". Table 1 shows the results for the showcase farm. The "Farm Fact Book" consists of the following elements: "Basic information", "Natural conditions", "Machinery", "Human resources", "Buildings", "Farm details" and "Infrastructure".

The "Basic information" includes details about the "Legal status", "Mode of operation", and the "Aim of operation". The examined farm is like the vast majority of German farms an independent business, meaning that the farmer is personally liable for his farm. Despite the fact that the spouse of the farm is working externally the farm is considered a "Main income farm" since the farm supplies major funds to the total household income. The "Aim of operation" is of special interest respecting the scope of this paper. Unsurprisingly the farmer named profit maximization as one goal. Moreover he plans to further develop "Direct marking" in connection with "Strawberry cultivation", since he considers this a growing market in the future. The most interesting point however, is the fact that the farmer himself obviously estimates that there is some optimization potential within his farm. This self-induced recognition plays a major role for the motivation later on during the introduction and application phase of the FMIS. As for every farming business the "Natural

conditions" are of vital importance. For the examined farm one can state that these conditions are favorable. Climate and rainfall supply good weather conditions for land cultivation. Additional most the soil used for cultivation is of extraordinary quality. The so called loess soil is one of the riches soils existing. The soil quality of the farms location is comparable with the fertile areas like the "Soester Börde" and the "Mageburg Börde".

Basic information	
Legal status	Agricultural independent business
Mode of operation	Main income farm
Aim of operation	Profit maximization Expansion strawberry cultivation/Direct marketing Optimal coordination of all farming activities

Buildings	
Pig stall (Slatted floor)	
No. of places	750
Subfloor liquid manure storage	900m3 capacity
Animal feed silos	2; Capacity 20t (12t and 8t)
Horse stable	11 Litter bays (3 with outdoor paddock)
Barns	3 (650m2 total area)
Grain elevator	200t

Natural conditions	
Elevation	104m above sea level
Climate	Sub Atlantic climate with continental influence
Rainfall	680mm-800mm per year
Average temperature	8,9°C
Sunshine	1.435 hours per year
Soil classification No. (crop land)	64 Points
Soil classification No. (grassland)	48 Points
Terrain	Northern location on a slope of the Wiehengebirge, Flat country (North German Plain)

Farm details	
Productive Land	91,7ha
Agricultural land	72,6ha
Forrest	11,0ha
Grassland	6,9ha
Farm area	1,2ha
Husbandry	
Hogs	750
Race	Danish landrace/Pietrain
Annual production	1950 hogs
Average slaughter weight	94,5kg
Pension horses	11 (different races)

Machinery	
Tractors	2 (96 PS/85PS with Front loader)
4 mould board plough	1
Grubber	1
Rotary cultivator	1
Cambridge drum	1
Sowing machine	1
Fertilizer spreader	1
Hay rake	1
Square baler	1
Tedder	1
Mulcher	1
Agricultural sprayer	1
Straw chopper	1
Rotary mower	1
Slurry tanker	1
Manure stirring device	1

Infrastructure	
Internal Infrastructure	All buildings are located close to each other and are connected by a paved area, the pig stall is located 400m away from the actual farm and accessible over a public tarred road Crop area partially adjoining the farm Majority of cropland is located within a distance of 3 km (90% of cropland) Some strawberry fields lie up to 20km distant All crop areas are accessible by paved roads (partially dirt roads)
External Infrastructure	
Slaughter house	1,5km
Inland port	2,5km
Animal feed suppliers	25-100km
RidingSchool	200m

Human resources	
Permanent personnel	
Operating manger (Owner)	1
Skilled helper	1
Seasonal personnel	
Foreign pickers	15
Vendors	35

Table 1: Farm Fact Book

The "Machinery" is generally in good condition, maintained regularly and on the latest state of technology. The two tractors represent the only exceptions. Both are more than 20 years

old and although they were completely overhauled seven years ago they are not up to date. Thus the farmer intends to replace them within one year time.

The "Human resources" display three different types of employees. The farmer employs one additional full time helper. Due to the natural variation in work load between summer and winter a time account provides the flexibility needed. Beside the full time helper the farmer employs 15 foreign pickers and up to 35 vendors during the strawberry and raspberry season. Most pickers are of Polish origin whilst the vendors are mostly German pensioners, students or pupils. According to their occupational background all employees are either marginal employed or short term employed, to achieve a minimum tax charge.

"Buildings" incorporate all premises need for the production processes. The "Pig stall" was erected in 1978 and augmented in 1990 to a capacity of 750 hogs. The installation of a fully automated feeding system at the same time reduced the workload per hog dramatically. The stall serves additionally as a platform for solar panels. The 11 boxes for the pension horses are accommodated in two buildings, both build in 1975. Three boxes with outdoor paddock situated in one building, the residual ones in another. The average size of the boxes amounts to 16m2 and all are equipped with automated drinking water supply. Barely- and wheat-straw serves as litter. All barns are more than 40 years old, however well maintained and appropriate equipped for storing machinery, tools, etc.

The "Farm details" display, how the 91,7ha "Productive land" are split up. As one can see the agricultural land represents by far the largest share. Forrest contributes the second largest part; however, its effect on the farm's total profitability is minor.

The "Internal" as well as the "External infrastructure" are advantageous. Concerning the internal infrastructure one can state, that all production facilities are located centrally at the farm. The majority of cultivated land is closely situated as well. Some strawberry fields represent exceptions, yet. The preference of many customers to swiftly access strawberry field for self-picking causes the wide dispersion of the fields. The "External infrastructure" provides all facilities to source raw material and to sell finished products cost efficient. The close-by riding school causes a constant need for horse boxes. The fact book provides valuable input for the setting up of the actual FMIS. It contains all the basic information needed for a germane development of the model and it helps the researcher to better understand of the farm's productions processes and their interdependencies.

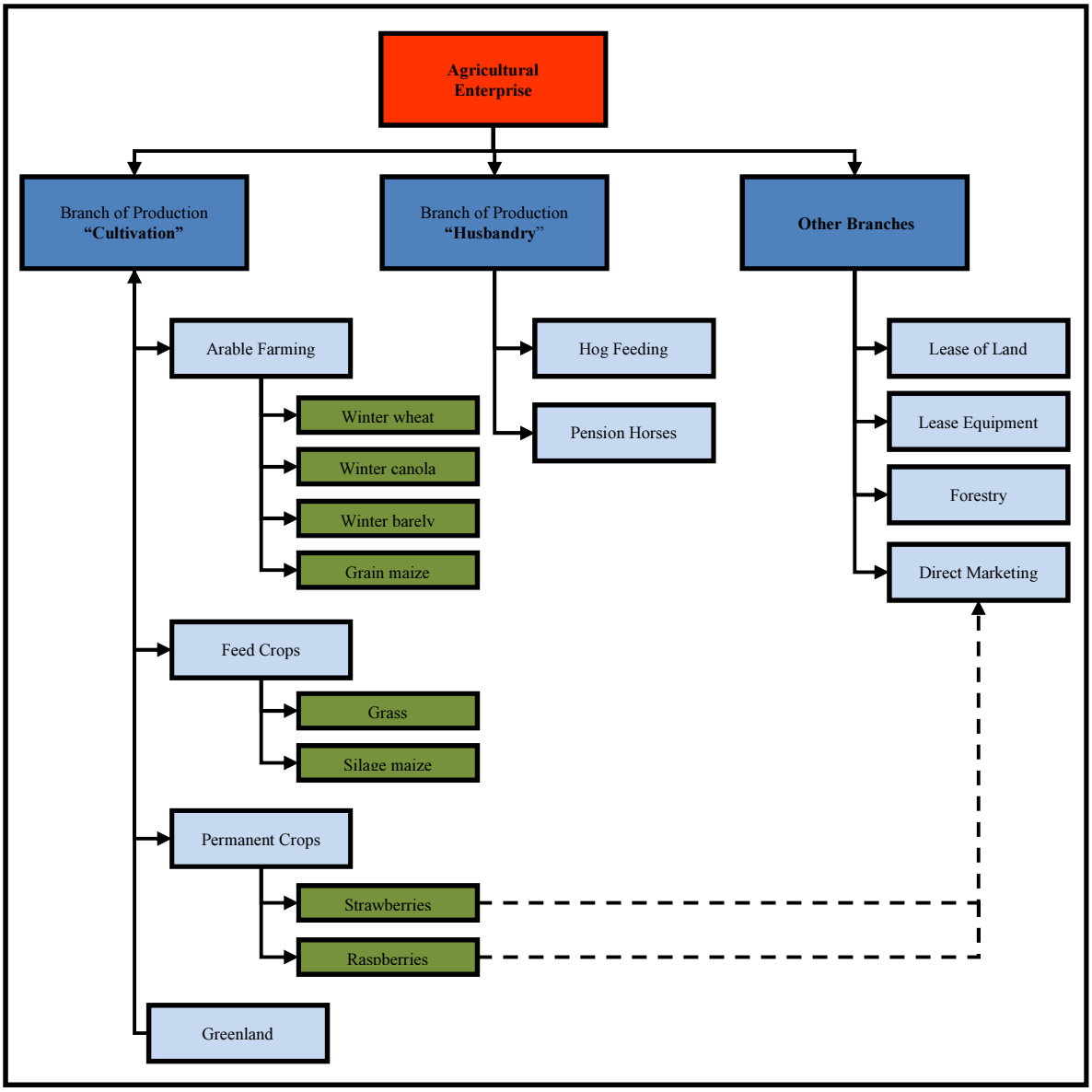

Figure 2: Production Branches Classification

The next step incorporated a classification of all production processes, displayed in Figure 2. The case-study farm has three major braches, namely "Cultivation", "Husbandry" and "Other Branches". The branch "Cultivation" has four subunits. The first "Arable Farming" displays the three main crops, which the farmer cultivates. These crops follow the common regional scheme of crop rotation: winter wheat, winter barely, winter canola. "Feed Crops" incorporates grassland for the hay production and grain maize which is sold to food suppliers who meliorate and resell it as pig feed to the farmer. The pasture is exclusively used for the horses during the summer. The "Permanent Crops" are of particular importance for two reasons. Both together strawberries and raspberries contribute substantially to the

total farm income. They are the only products sold directly to customers and are therefore closely related to "Direct Marketing". The second major branch "Husbandry" consists of "Hog feeding" and "Pension Horses". The last branch "Others" consist of "Lease of Land", "Lease of Machinery", "Forestry" and the mentioned "Direct Marketing". Subsequently, according to the identified production processes developed contribution margin model is displayed in Figure 3. The contribution margins have different dimensions depending on the production process they refer to. For all "Cultivation" processes as well as for the "Lease of Land" and "Forestry" the dimension is EUR/ha since hectare is the limiting resource. This approach facilitates also the treatment of so called co-products (grain and straw of wheat for instance). The surge of complexity caused by splitting up machine and labor hours or fertilizer quantities and so on would not be paid off by the increase of information.

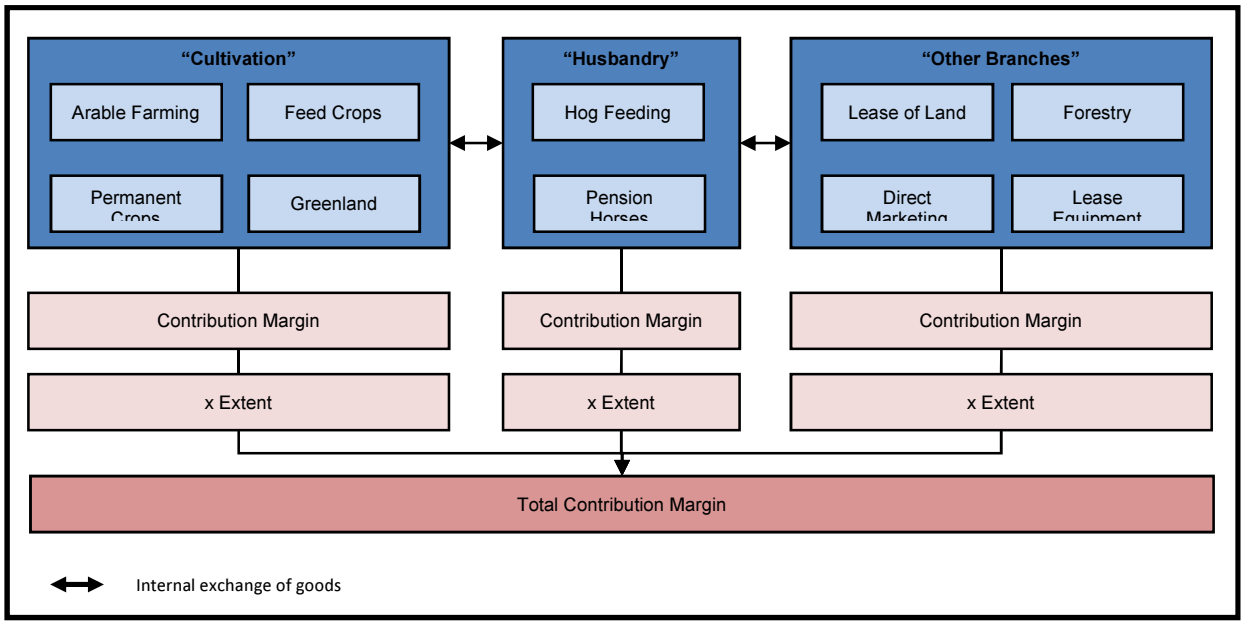

Figure 3: Contribution Margin Model

For all "Husbandry" processes the limiting resource is the number of places, so the dimension is EUR/place. The "Lease of Equipment" is measured in EUR/machine hour. When these dimensions are multiplied with the extend number of hectare, animals, machine hours) one receive the contribution margin of each single production process. Underlying to this simplified model an extensive product-costing model has to exist. Since the authors perceive all products marketable, the revenue is calculated as market price multiplied with the quantity. A special role plays the process "Direct Marketing" because it receives its products exclusively from the production branch "Permanent Crops". In this case authors replaced the market price by the cost of production. So the contribution margin of the

"Permanent Crops" will be always zero and a potential positive or negative contribution margin occurs only in "Direct Marketing". This exceptional relationship is displayed in Figure 4. Beside this most important independency, Figure 4 shows four more internal transfers of goods. The cultivated grain maize is missing in this figure although it is partially

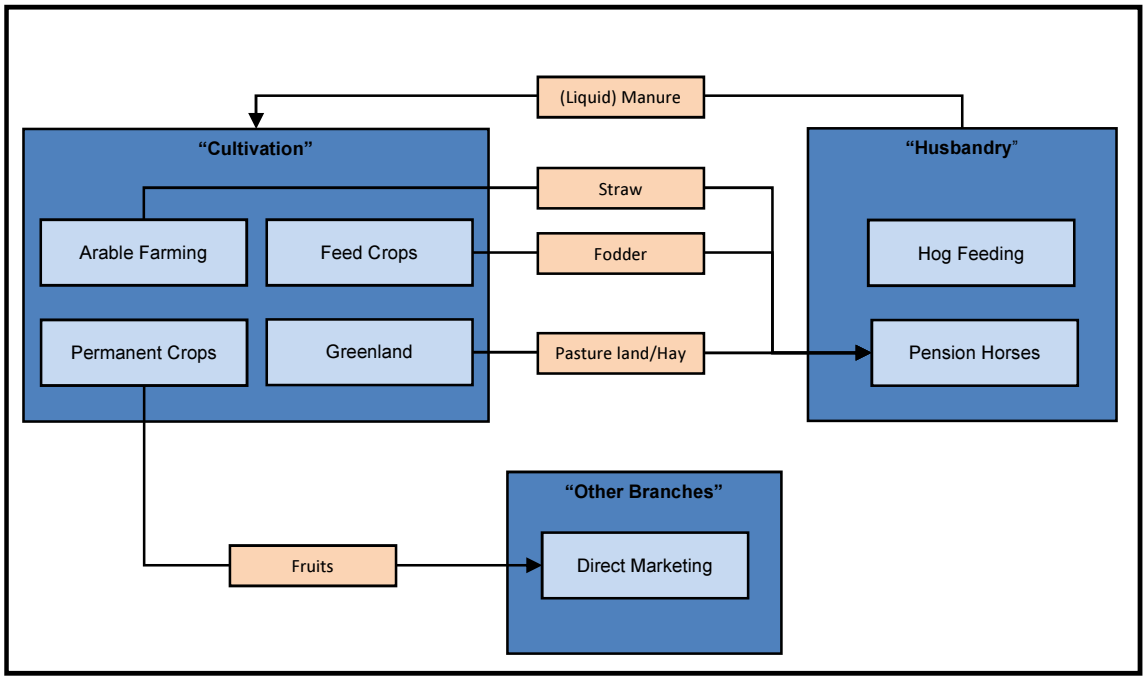

Figure 4: Internal Interrelations

fed to the hogs. Authors excluded the maize here because a supplier buys and ameliorates it and finally resells it to the farmer. Thereby an external party is involved.

DISCUSSION

In the last 40 years the German agricultural sector has been exposed to a much more complex and faster changing environment than ever before. An increasing risk level accompanied this development. Reasons are factors like the progressing liberalization of the world markets in general and of the markets within the European Union in particular, a constantly changing juridical situation and a higher refinancing risk, triggered by the financial crisis(Weiss & Thiele, 2002)(Berg, Schmitz, Starp, & Trenkel, 2005). The exposure of German farms to the refinancing risk has been increasing over the past decades since the leverage factor of farms has surged. This fact is caused by the rising level of mechanization and technology which consequently has led to higher capital intensity. Therefore managing financial risks becomes critical for the surviving of many farms (Drollette, 2008). Because of the fact mentioned, it has become extremely difficult for

farmers to take correct management decisions. Additionally, the consequences from incorrect decisions are more severe than before since the effect on the equity ratio can be tremendous.

A good indicator, for the increased number of difficulties German farmers have to deal with, is the change of the total number of farms. As Figure 5 indicates, it decreased from 927.906 in 1974 to 374.514 in 2007. This represents a loss of nearly 60%(© Statistisches Bundesamt, 2012).

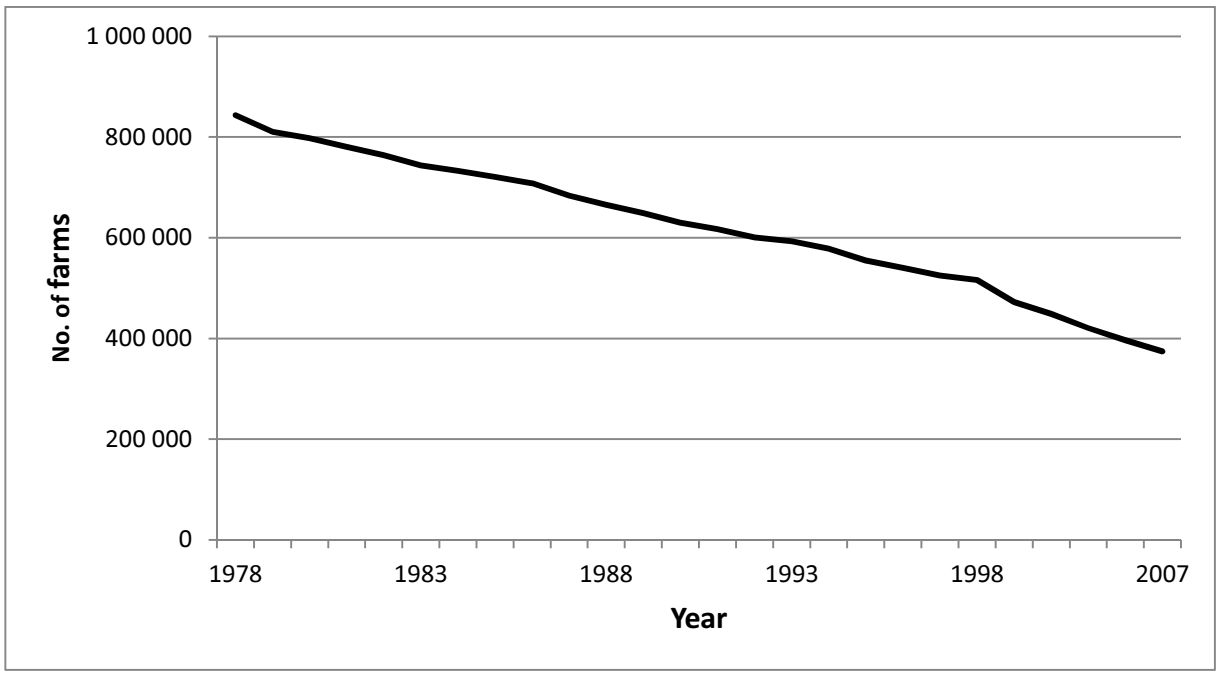

Figure 5: Total Number of German farms 1978-2007

The remaining farmers have mainly reacted to the new conditions in four ways. Many abandoned their farming business as already mentioned and searched for a job or started a different kind of business. Some got employed at firms nearby and became part-time farmers. Others have augmented their farms in order to benefit from economies of scale (Nause, 2003). The last group has tried to diversify their farming business by cultivating for example special crops and/or generating other sources of income (e.g. pension horses, farm shop etc.) which allow the exploitation of economies of scope. This differentiation of the total farm income has a stabilizing effect on the entire farm business (Glauben, Tietje, & Weiss, 2006). The advantage of diversified farms lies in particular in their lower exposure to a single risk factor (Weiss & Thiele, 2002).

For the augmented and for the diversified farms a proper management has become a sophisticated task which demands additional skills from farmers. Prior it was sufficient to

have expert knowledge in land cultivation and stock breeding, which is, however, not adequate any longer. Farmers had to shift their self-perception from the "classical" role as a cultivator and breeder to a manger of an enterprise. Therefore, they have to gain knowledge in risk assessment, controlling, auditing and taxations. All this holds in particular true for diversified farms since they do not only have to deal with the new conditions and they elevated risk level, but also with their complex farm-structure. Thus they are in need of a sophisticated planning, controlling and optimization tool.

The farmer is of most important source of information among all the mentioned sources above since his through knowledge about the farm processes is indispensable. Therefore the interviews are of special prominence. Another reason why the interviews are of such high importance is the fact that the farmer has to be involved in the model developing process from the very beginning. Many researchers so far have underestimated that the farmer and his family, their values, believes, intensions and capabilities have a tremendous impact on the successful implementation of FMIS.Moreover scholars start accepting farmers as equal and equitable colleagues and encourage them to participate in the development process (McCown & Parton, 2006).

CONCLUSION

The findings of this paper have pointed out that well balanced and mature management decisions are more important for the surviving of farms than ever before. Reasons are the grown external and internal complexity of the farming business and its higher exposure to financial risks. It is likely that these factors will become even more significant in the future. Considering the difficult situation German farmers are facing to today and the decrease of total number of farms, a professional decission making support system is required. A sophisticated FMIS can be an important contribution to deal with the difficult situation to attain better management decisions.It has to allow farmers to easily access all information which are crucial for the farms profitability.

The minimum requirements for such a FMIS are:

1. Monitoring/Data collection
2. Planning/Scenario analysis
3. Controlling/Target-actual comparisons
4. Identification of optimization potentials /Profit maximization

However, one has to consider the enormous effort connected with a proper setting-up of a FMIS. Co-products, internal exchange of good or non-marketable products (e.g. crop-

rotation) and a thorough cost accounting as a basis are just some factors which have to be considered. Moreover, when it comes to optimizations (profit maximization), an allocation optimum for the entire farm is difficult to identify, since the scare resource differ from production process to productions process (ha, places, machine hours). Nevertheless, authors are convinced that the benefits of a FMIS are paying off for farmers on the long run. A well-developed MIS can support a decisions making process which is based on facts and not on gut instinct.

LITERATURE

© *Statistisches Bundesamt, W. (2012, January 17). Statistisches Bundesamt Deutschland - GENESIS-Online. Text. Retrieved January 17, 2012, from https://www-genesis.destatis.de/*

Arrow. (1993). I know a hawk from a handsaw. In M. Szenberg (Ed.), Eminent Economists: Their Life Philosophies. Cambridge University Press.

Berg, E., Schmitz, B., Starp, M., & Trenkel, H. (2005). Weather derivatives a risk management tool in agriculture. German Journal of Agricultural Economics, 54(3). Retrieved from http://ideas.repec.org/a/ags/gjagec/97213.html

Bokelmann, W., Hirschauer, N., Nagel, U. J., & Odening, M. (1996). Landwirtschaftliche Beratung in Brandenburg. Eine Evaluierung erster Erfahrungen. Weikersheim: Margraf.

Doyle, C. J. (1990). Application of systems theory to farm planning and control: modelling resource allocation. In J. G. W. Jones, P. R. Street, & C. R. W. Spedding (Eds.), Systems theory applied to agriculture and the food chain. Springer.

Drollette, S. (2008, March). Managing Financial Risk in Agriculture. Utah State University, Department of Applied Economics.

Forster, R. (2002). Methodische Grundlagen und praktische Entwicklung eines Systems zur Planung dispositiver Arbeiten in landwirtschaftlichen Unternehmen. Text.PhDThesis. Retrieved March 24, 2012, from http://deposit.ddb.de/cgi-bin/dokserv?idn=965172260

Gerring, J. (2004). "What Is a Case Study and What Is It Good For?" American Political Science Review, 98(2), 341–354.

Glauben, T., Tietje, H., & Weiss, C. (2006). Agriculture on the move: Exploring regional differences in farm exit rates in Western Germany. Jahrbuch für Regionalwissenschaft, 26(1), 103–118. doi:10.1007/s10037-004-0062-1

Makeham, J. P. (1971). Farm management economics. Armidale, New South Wales: Gill Publications.

Malcom, L. R. (1990). Fifty years of farm management in Australia: survey and revie. Review of Marketing and Agricultural Economics, 58(1).

McCown, R. L., & Parton, K. A. (2006). Learning from the historical failure of farm management models to aid management practice. Part 2. Three systems approaches. Australian Journal of Agricultural Research, 57(2), 157. doi:10.1071/AR05052

Mußhoff, O., & Hirschauer, N. (2006). Die Rehabilitation von Optimierungsverfahren? - Eine Analyse des Anbauverhaltens ausgewählter Brandenburger Marktfruchtbetriebe. In E. Bahrs, S. von Cramon-Taubadel, A. Spiller, L. Theuvsen, & M. Zeller (Eds.), Unternehmen im Agrarbereich vor neuen Herausforderungen,

Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues (GeWiSoLa) (Vol. 41, pp. 495–505). Münster-Hiltrup: andwirtschaftsverlag GmbH.

Nause, G. (2003). Zur Entwicklung der in den landwirtschaftlichen Betrieben Deutschlands beschäftigten Arbeitskräfte 1991 bis 2001. Statistisches Bundesamt, Wirtschaft und Statistik, 301–313.

Pannell, D. J. (1996). Lessons from a Decade of Whole-Farm Modeling in Western Australia. Review of Agricultural Economics, 18(3), 373–383. doi:10.2307/1349622

Sorensen, J. T., & Kristensen, E. S. (1992). Systemic modelling: A research methodology in livestock farming. In A. Gibon & B. Matheron) (Eds.), Global appraisal of livestock farming systems and study on their organisational levels: concept, methodology and results: proceedings of a symposium (pp. 45–57). Toulose, France: Commission of European Communities.

Weiss, C., & Thiele, H. (2002). Diversifikation und Wachstum landwirtschaftlicher Unternehmen, 51(3), 156–163.