Impact matrix analysis and cost-benefit calculations to improve management **pr**actices regarding health status in **o**rganic dairy farming

Project Number: 311824

- Deliverable -

D6.4 - Herd health management tool

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Deliverable Lead Partner:	P1 University of Kassel
Deliverable Author(s):	Susanne Hoischen-Taubner, Werner Feucker

Executive Summary

This document describes the scope and prefiguration of the IMPRO Software Toolbox. The toolbox contains six tools: (1) Herd monitoring tool, (2) Impact Matrix, (3) Cost-benefit module animal health, (4) Profitability assessment dairy cow, (5) Proactive and preventive protocols, (6) Decision trees and Anamnesis tools for alternative treatments. Thereby, the toolbox covers different aspects of the complex challenge of herd health management. It will be used by farm advisors and veterinarians as well as dairy farmers by promoting a participatory approach and by supporting decisions in relation to animal health and economics while following the *equifinal* approach of IMPRO.
The usability and usefulness of the current version will be tested on 24 organic farms in NL and UK. The results are expected to lead to further improvements in the toolbox. Therefore, this document does not reflect the final state of the toolbox and will be updated by the end of the IMPRO project.

Dissemination Level		
PU	Public	PU

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1 Introduction

Organic as well as conventional dairy farmers are facing with an increasing interest of consumers in the issue of animal health and welfare. Ensuring a high animal health status in a dairy herd requires huge efforts in adjusting care, feeding and treatments to cow individual needs in a situation where the availability of resources (e.g. labour capacity, investments) within the farm systems is restricted.

Research activities within the IMPRO project are targeted to improve decision making regarding animal health on a farm level. Within different workpackages several tools were created and applied. They foster a diagnostic procedure on the farm level, taking the farm specific conditions, economic factors as well as animal based information regarding the herd health status into account.

Tools from the workpackages are compiled to the IMPRO toolbox. The current version is a prefiguration (beta-version). Some tools are still under further development (e.g. protocols from WP3). The toolbox will be tested by 24 dairy farmers and their veterinarians / advisors in The Netherlands and the United Kingdom. Results from the test phase will be used to improve the usability of the software tools.

2 Objectives

According to the objectives within the IMPRO project, the software tool will serve different functions:

- As the animal health status is the outcome of a complex network of interconnected factors and the interactive structure of the whole farm system, a systemic approach is required to elaborate the most accurately fitting recommendations from subjectively biased appraisements. The **Impact matrix** has been developed as a software tool to facilitate a participatory and farm-centric diagnostic procedure applied in WP2. The impact matrix provides a structure to include and moderate the different perspectives, experiences and knowledge of farmers, advisors and veterinarians. It supports the identification of those measures in the farm context, expected to improve the prevalence rate of production diseases and replacement rates.

- **Cost-benefit calculations** are crucial to identify the most efficient measures and to show where investigations in animal health management may result in monetary benefits that exceed the investments and contribute to additional values. Therefore, a tool to estimate farm-specific failure costs as well as future preventive costs of measures is part of the toolbox.

- A pro-active **herd monitoring protocol** adapted to organic dairy production will be a further software tool. Protocols for monitoring and prevention of the major clinical and sub-clinical diseases (mastitis, lameness, reproductive and metabolic disorders) will improve proactive strategies as the basis of decision making.

- **Decision trees and anamnesis tools** focussing on the production diseases mastitis, and metabolic as well as fertility disorders, will support the selection of measures for an appropriate therapy of production diseases taking into account the use of alternative remedies.

Altogether the software follows a comprehensive herd health diagnosis and monitoring concept including different sources of data. The toolbox will serve as a decision support tool for improvement of the herd health management. The target groups are farm advisors and veterinarians as well as dairy farmers. Furthermore, the set of tools will be helpful to make the complexity of farm systems accessible to scientists from different disciplines.

3 Description of the toolbox

The toolbox contains several tools that might be used separately but complement each other in aiming for a prioritisation of measures in relation to a specific farm situation (Figure 1).

1. Within IMPRO workpackages 2, 3, 4 and 5 information on the herd health situation were gained from milk recording data. The IMPRO-toolbox provides an overview on the farm specific herd health situation according to indicators applied in the different workpackages, based on milk recording data.

2. The Impact Matrix tool was applied in WP2 and proved to support the systemic analysis of a complex farm situation in a participatory approach.

3. Costs and losses due to the level of production diseases are calculated with the "cost calculation tool animal health", developed in WP5. Based on selected measures and estimated efficiency the failure and preventive costs for a future situation are assessed.

4. The profitability assessment refers to farm specific economic data (annual accounts) as well as performance data (milk recording data) and enables a profitability analysis by comparing different self-defined sub- groups (e.g. healthy and diseased cows) within a dairy herd.

5. Monitoring and preventive protocols elaborated in WP3 are still under investigation. A final version will be available by June 2016. So far a protocol to support the monitoring on farm and an overview on indicators for the monitoring and alert levels are included in the toolbox.

6. In WP4 decision trees and anamnesis tools in relation to the different production diseases (mastitis, metabolic and fertility disorders) as well as a monitoring protocol for treatments while taking homeopathy into account were elaborated and are available in the toolbox.

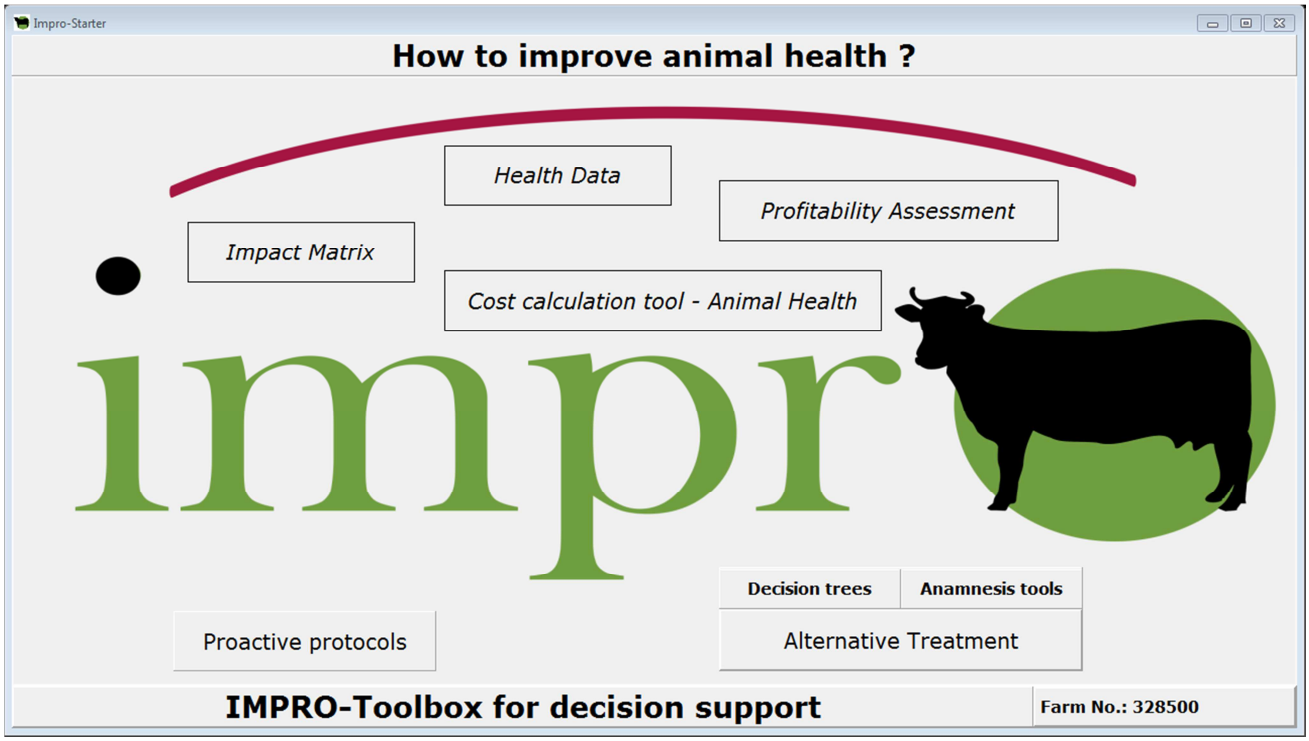

Figure 1: Main screen IMPRO Toolbox

4 Specification of software features

4.1 Herd monitoring tool and Overview on Herd-Health data

Improvements of animal health will only be possible if herd health plans are designed and targeted specifically in response to the individual farm, requiring a comprehensive herd health monitoring concept. Information on the herd health status can be obtained from milk recording data.

The Data Service Paretz Ltd. refined and enhanced their herd management software "HERDE^{plus}" considering the demands of all project partners regarding an intensive health controlling and monitoring. In this regard, the focus was on the assessment of milk recording data, including milk yield and milk compounds (fat, protein, urea, somatic cell count) in combination with performance indicators for fertility and reproduction.

As basis for this assessment in "HERDE^{plus}", an efficient data collection and easy user-friendly handling has been realized. Essential data on performance and health of individual animals are recorded and stored from entering until leaving the farm. Additionally, data are used for permanent monitoring of performance as well as for a continuous intensive process and effectivity control on herd and animal level. In terms of an early warning system, operational weak points are indicated by the software in due time.

Evaluations of animal health are based on herd data. If not recorded directly by the users (farmers, advisors, veterinarians) on a daily base, required data can also be accessed from laboratories of the milk recording companies and central data centres. Data interfaces were developed on an international level and common definitions of indicators form the basis for a standardized use of data across all countries participating in the IMPRO project. For countries using the diagnosis codes of the International Committee on Animal Recording (ICAR), an additional analysis of the prevalence of different types of diseases is accessible.

The following range of topics represents the main areas for the evaluation of animal health

- **Evaluation of udder health**
  To evaluate and reduce high somatic cell counts, time, location, and cause of infection is taken into account. Positive or negative trends in development can be shown on a monthly basis for analysing the impact of a change of feed, season etc. on somatic cell count, milk yield and milk compounds. To evaluate the success of dry cow treatment, the healing rate during dry period, the rate of new intramammary infections during dry period, the rate of heifers infected with mastitis as well as the numbers of cows with recurrent high somatic cell counts are calculated.

- **Control of feeding and body condition**
  Analysis of milk yield and milk compounds provide a valuable feedback to promote balancing of the nutrient supply or to provide warning signals for specific nutritional deficiencies and metabolic diseases such as: under- or oversupply of energy and protein, emaciation, risk for obesity, fatty liver syndrome after calving or risks for subclinical ketosis and acidosis.

- **Analysis of fertility and reproduction**
  A quantification of the success of artificial insemination (considering the influences of heat observation and detection, start of first insemination, control of recurrent heat after insemination, management decisions regarding the voluntarily waiting period, number of inseminations etc.) affecting the calving interval and thus the profitability of the farm is performed. Calf mortality and culled cows are displayed with reasons for culling and lifetime

productivity. The latter is important for the evaluation of the economic impacts of diseases in the following “Profitability Analysis Cow”.

For international use, the program “HERDE^{plus}” and “Profitability Analysis Cow” has been translated into English. A test run for international use of the programs with data of two Dutch farms was successfully conducted. Currently, “HERDE^{plus}” is primarily used in Germany. For the project partners all required evaluations are prepared and provided by Data Service Paretz Ltd.

Overview on Herd-Health data

For the test-phase, the IMPRO-Toolbox will contain an overview on the farm specific herd health status based on evaluations made by HERDE^{plus}.

A timeline of milk recording results shows the milk yield, fat, protein and milk urea content, as well as the somatic cell count based on test-day results in a time period of 12 month (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The representation in line graphs allows for an estimation of changes in the time-period and recognition of trends.

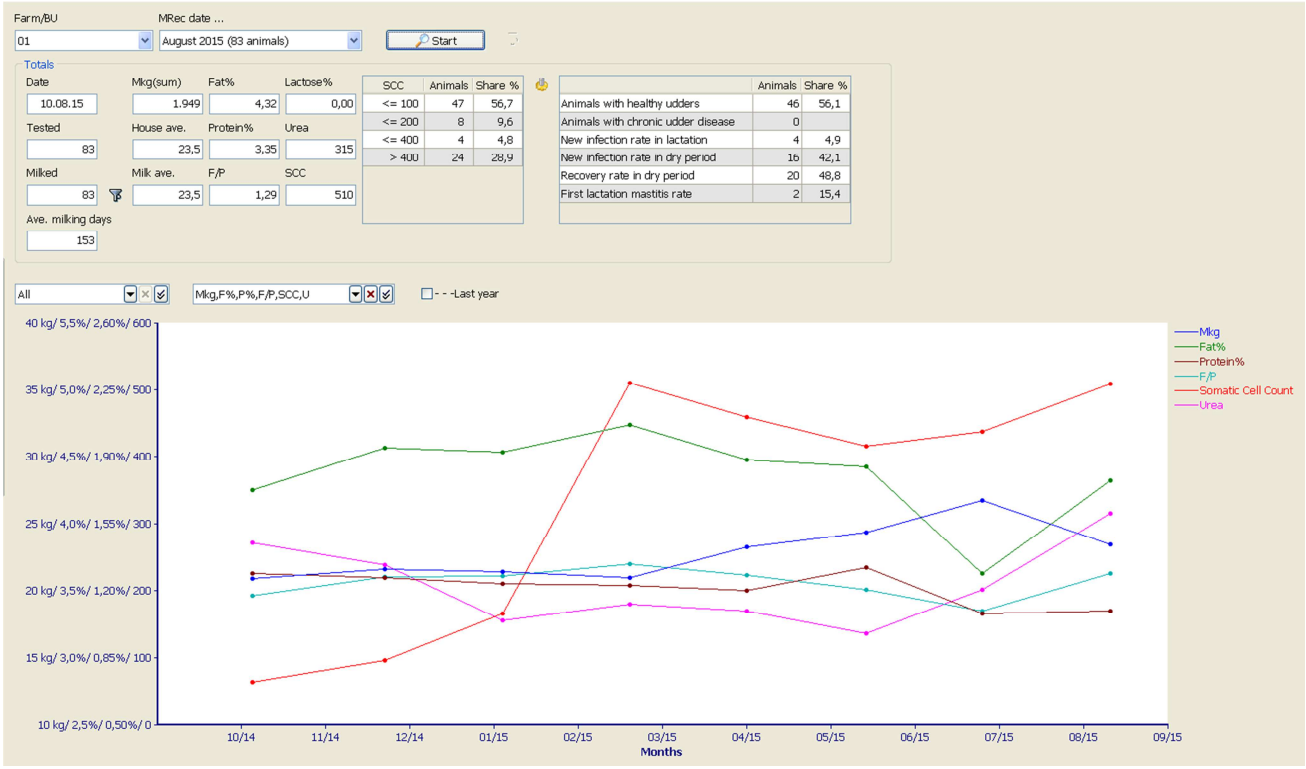

Figure 2: Timeline of milk recording results: milk yield (Mkg), fat content (F%), protein content (P%) SCC (somatic cell count), milk urea content for a time period of 12 months

The graphical representation of milk content is supplemented by a table, providing a more detailed representation of the proportion of cows in the herd in specific cell count classes (Figure 3). Apart from the average somatic cell count the proportion in classes allows for a more detailed assessment of the differences between the categories.

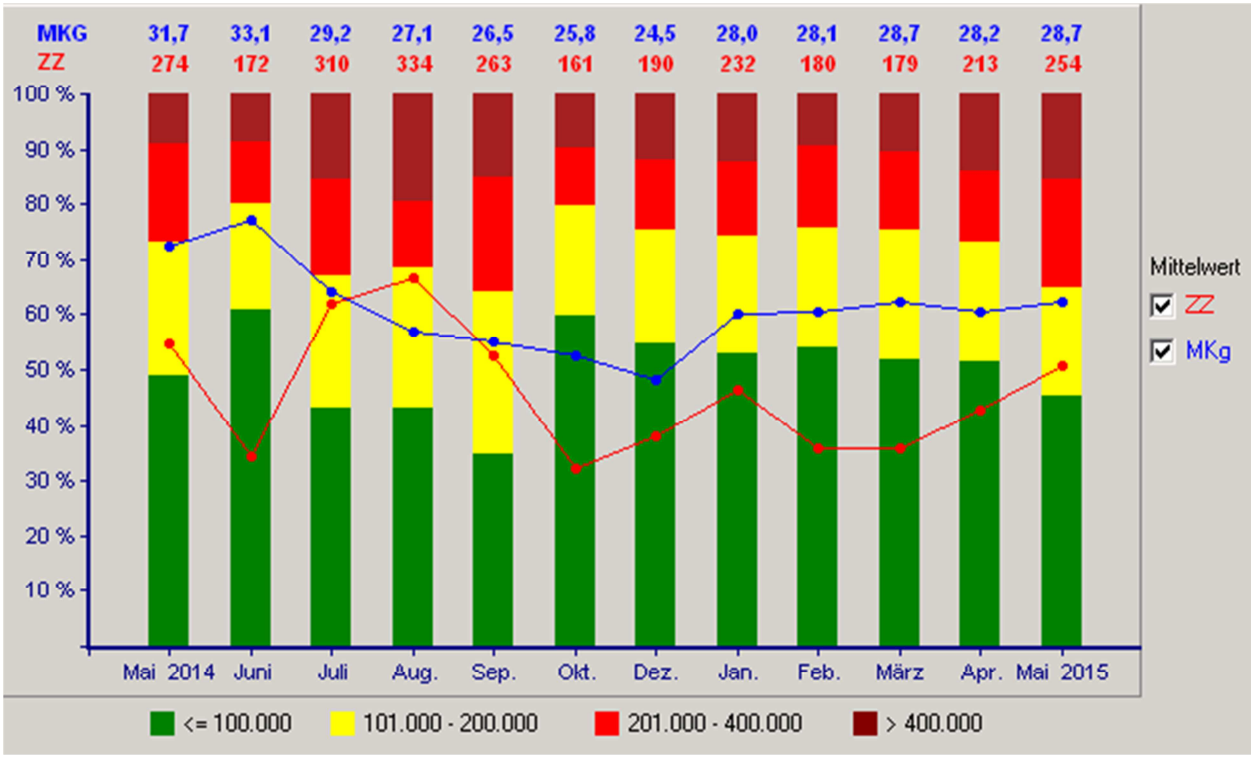

Figure 3: Overview on proportion of cows in somatic cell count classes in a time period of 12 month

The analysis of milk content allows for an assessment on how far the feeding requirements of lactating cows are met. A lack of energy in the daily feeding ration may cause clinical or subclinical metabolic disorders which might pave the way for infectious diseases. The same applies for a lack of fibre, while at the same time an excessive supply of protein may challenge the metabolism.

The relationship of milk fat and milk protein allows for an assessment on how far the feeding requirements of lactating cows, based on their individual milk yield, are met. Cows in risk of ketosis can be identified as well as a feeding situation fostering a risk of acidosis by a lack of crude fibre (Figure 4). The figures shows the fat/protein ratio for each cow of the herd and stage of lactation (days in milk), based on milk recording data in one month.

Further information on the energy and protein supply of lactating cows can be gained by assessing the relationship between protein content and milk urea content by the stage of lactation (Figure 5).

The analysis of the feeding situation is given in two figures each: one representing the feeding situation during winter and one for the feeding situation during summer.

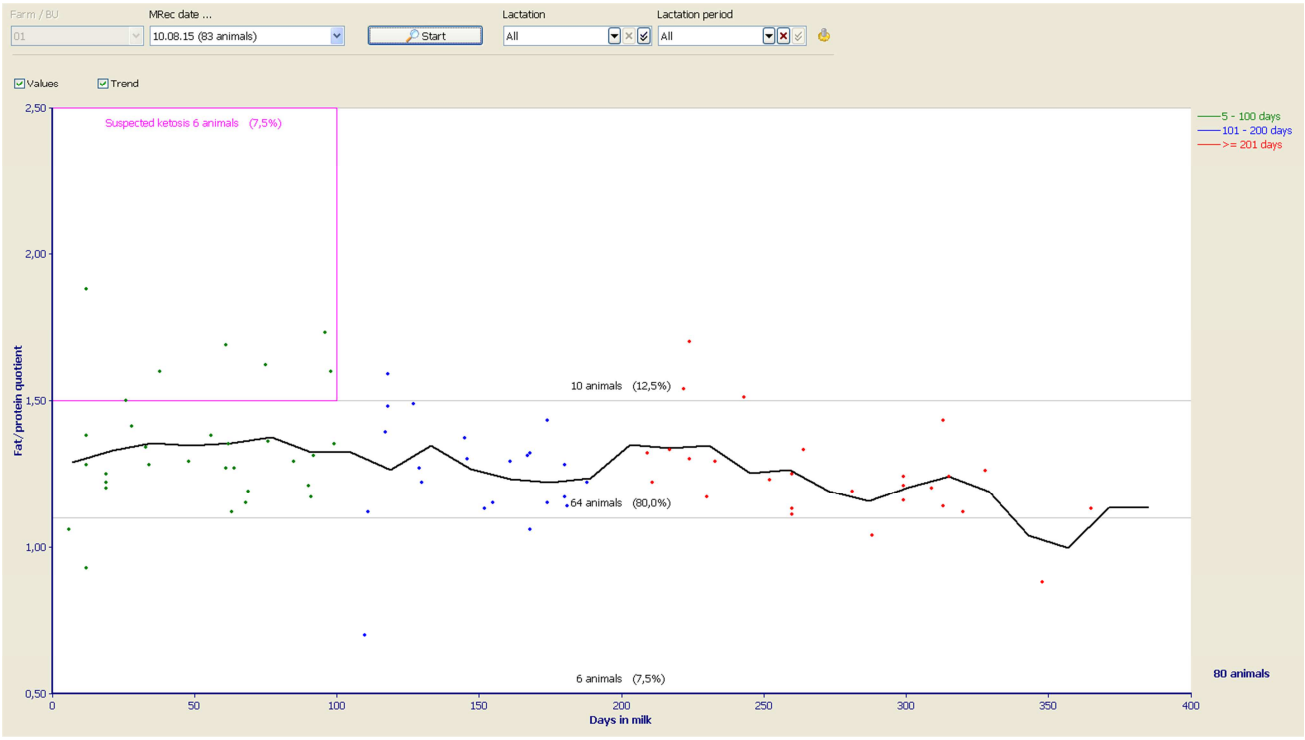

Figure 4: Fat / Protein ratio for single animals

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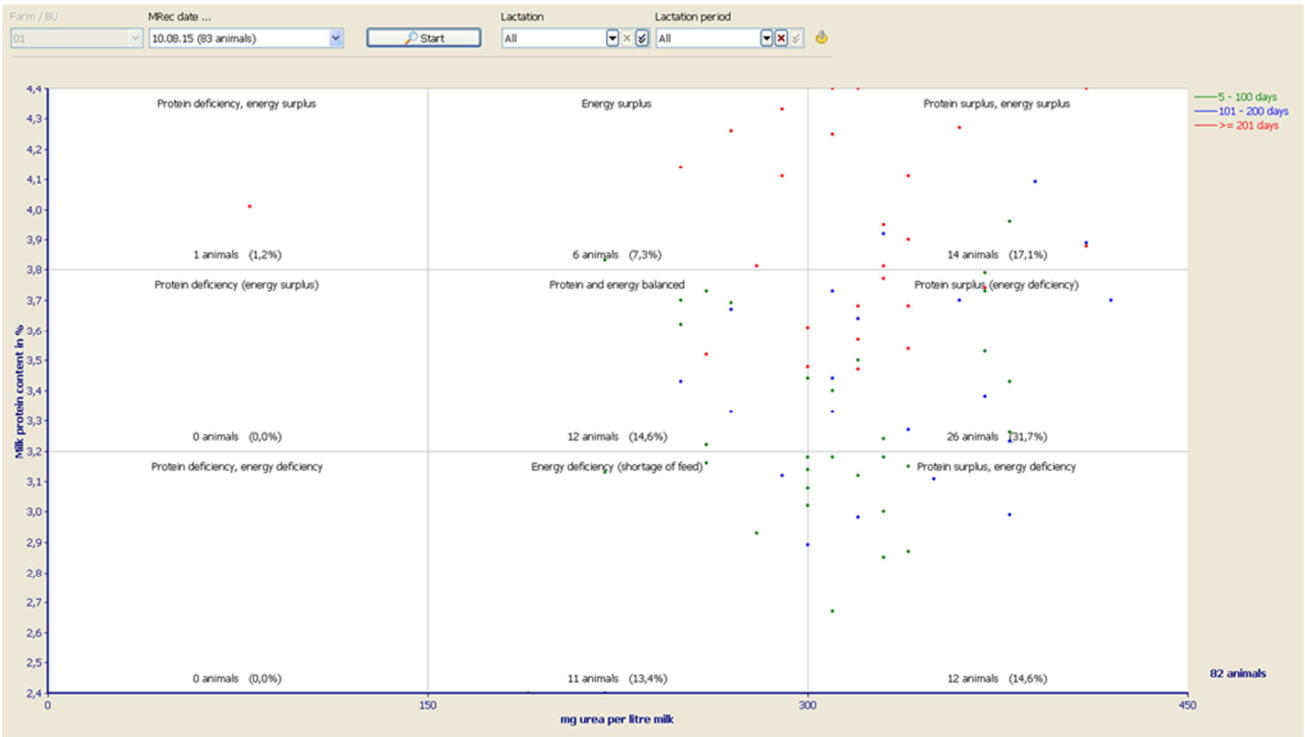
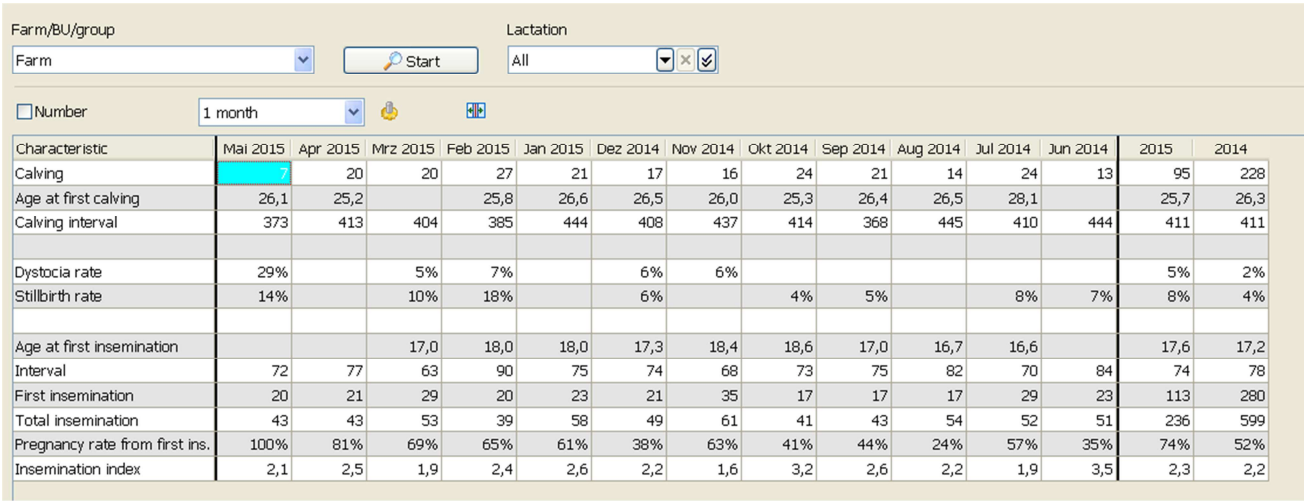


Figure 5: Milk protein and urea contents of single animals

Information on the average number of animals in the herd, the proportion of culling and the average productive life for three consecutive years are provided in a table as well as information on fertility like the number of calving, age at first calving and calving interval (Figure 6).



Characteristic	Mai 2015	Apr 2015	Mrz 2015	Feb 2015	Jan 2015	Dez 2014	Nov 2014	Okt 2014	Sep 2014	Aug 2014	Jul 2014	Jun 2014	2015	2014
Calving	7	20	20	27	21	17	16	24	21	14	24	13	95	228
Age at first calving	26,1	25,2		25,8	26,6	26,5	26,0	25,3	26,4	26,5	28,1		25,7	26,3
Calving interval	373	413	404	385	444	408	437	414	368	445	410	444	411	411
Dystocia rate	29%		5%	7%		6%	6%						5%	2%
Stillbirth rate	14%		10%	18%		6%		4%	5%		8%	7%	8%	4%
Age at first insemination			17,0	18,0	18,0	17,3	18,4	18,6	17,0	16,7	16,6		17,6	17,2
Interval	72	77	63	90	75	74	68	73	75	82	70	84	74	78
First insemination	20	21	29	20	23	21	35	17	17	17	29	23	113	280
Total insemination	43	43	53	39	58	49	61	41	43	54	52	51	236	599
Pregnancy rate from first ins.	100%	81%	69%	65%	61%	38%	63%	41%	44%	24%	57%	35%	74%	52%
Insemination index	2,1	2,5	1,9	2,4	2,6	2,2	1,6	3,2	2,6	2,2	1,9	3,5	2,3	2,2

Figure 6: Data on fertility and culled animals

4.2 Impact Matrix

An impact matrix is a concept for the application of a system approach to enhance an adaptive management approach. Vester & Hesler (1980) integrated the impact matrix in the sensitivity model, a software-based planning- and management tool for complex situations. Within IMPRO the impact matrix approach proved to foster a participatory diagnosis of a farm system. It aims at learning about the farmer's system of thought as well as the framework that allows for change in the farm context and provides a base for communication

Depending to a great deal on the estimations of the main decision maker on the farm, the farm specific characteristics as well as restrictions or limitations with respect to available resources are discussed among the participants (recommended: farmer, advisor and veterinarian), fostering a common understanding of interactions and limitations within the specific farm.

The basic concept is a square matrix built up by the system relevant variables, forming the rows and columns. The fields of the matrix, showing the impact from one variable to the other, are filled with figures from 0 to 3, representing the strength of influence. Calculating these figures reveals the systemic roles of each variable in the system in question.

The impact matrix tool in the IMPRO toolbox is based on the tool used in WP2 which was further improved according to lessons learned during the application and assessment of results. Currently the tool contains two prefigured sets of variables, one more general (13 variables) and one shorter variable set (8 variables). The list of 13 variables was used in WP2. It represents the perspective from a meta-level facilitating a view on the whole farm system. The level of aggregation covers the variation of structural differences between various organic dairy farming systems and the involved countries. The process and variables are presented in the deliverable D 2.2 of the IMPRO-project. The definitions given for each variable, as well as the indicators are described comprehensively and easily assessable within the software. Accounting for feedback from participants in WP2 a less time-consuming variable list is provided. Furthermore, individual variables sets, targeted to specific problem area can be created. However, the elaboration of a variable list requires insight in the methodology that still has to be described.

The impact matrix is filled directly in the software during the discussion. The software structures the discussion and supports the moderation which has to ask for effects between variables and the direction of the effect. The source variable (with definition and indicators) is shown on the left side, the target variable (with definition and indicators) on the right. To estimate the interaction between

two variables the question is: if the variable on the left (A) would change, to which degree would the variable on the right (B) react?

To score the effect between the variables a change in the source variable (A) is assumed and the impact on the target variable (B) estimated according to the following scheme:

- 0 ⇨ Negligible influence
- 1 ⇨ Disproportionately low influence (strong change in A → poor reaction in B)
- 2 ⇨ Proportional influence (change in A → equally strong change in B)
- 3 ⇨ Disproportionately high influence (minor modification in A → strong reaction in B)

After filling the matrix, systemic roles for all variables are calculated from active and passive sums in the rows and columns of the matrix. The result is presented in an output graph.

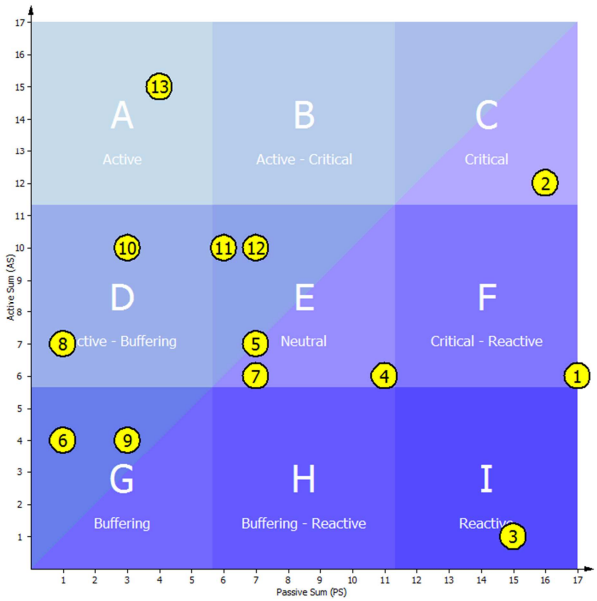


Figure 7: Example of a two-dimensional output diagram created at one farm where the role of the 13 system-relevant variables are identified

Experiences in WP2 revealed that the variables used in the matrix should be adapted to the farms specific situation. Therefore, in the toolbox different options for the impact matrix are provided: the very general set of 13 variables, used in WP2, and a more condensed set of 8 variables suitable to get to know a farm specific situation for a new advisor / veterinarian. The latter set will be used in the test-phase.

4.3 Failure and preventive costs

When facing the costs of diseases, failure and preventive costs should be distinguished. While failure costs are caused by (sub)clinically diseased animals (e.g. due to production losses, replacement and treatment), preventive costs are costs for management measures adopted by dairy farmers to prevent production diseases.

The “cost calculation tool animal health” is an easy to use Excel tool to estimate the failure costs of mastitis, lameness, ketosis and metritis based on technical and economic farm records. Furthermore, it estimates preventive costs for selected management measures. Preferentially, the model is completed in common by the farmer and the veterinary advisor. However, skilled and trained farmers should be able to complete the model as well.

Calculations in the model are based on (1) herd characteristics (milk production, number of dairy cows), (2) herd health characteristics (mastitis, lameness, ketosis and metritis), (3) price input (milk price, feed price, wage, replacement value, slaughter price, penalties, bonuses), and (4) farm characteristics (replacement rate, culling, death). Figures can be derived from milk recordings (somatic cell count classes, fat-protein ratio) and health recordings (alternatively farmers' estimates). Metritis has been divided into clinical metritis and subclinical metritis, diagnosis of these illnesses has to be performed by the farmer according to predefined definitions. Lameness requires input on lameness scoring; ideally hoof trimming records are used.

When all input data has been collected, the users have to decide which management measures they would like to implement on the farm. If the desired measure(s) is/are not included it/they can be manually added to the set of measures (up to 3 measures). Given the selected measures veterinary advisors/ farmers have to decide what the impact of the measures will be on animal health characteristics of the herd.

Failure costs are determined based on costs of (sub)clinical production losses, discarded milk, medication, labour, homeopathic treatment, culling and destruction. Country specific exemptions e.g. withdrawal period can be changed if these are not in-line with default values.

Preventive costs are estimated for each selected or added management measure based on costs for labour (costs of labour associated with performing the measure), consumables (costs of material necessary to complete the measure) and investments (costs of investments that are generally present on the farm for longer than one year).

Given the expected effect, the model estimates current failure costs, potential failure costs and potential preventive costs. The difference between the current failure costs and potential total costs is the effect of the management measures on farm income. Current preventive costs do not need to be determined as it is assumed that the current set of measures remains the same in the potential situation. When current costs are higher compared to potential costs the intervention programme improves farm income and vice versa.

(For a more detailed description see Deliverable D5.3 of the IMPRO project: Cost-Benefit relations of health related measures.)

4.4 Profitability assessment

Currently, animal data are mostly not linked to economic data. No connection is made between economic figures of a dairy farm and courses of individual lactations, diseases of cows, culling etc. To provide an economical evaluation of the livestock, animal production data from "HERDE^{plus}" were linked to costs and net proceeds from general economic farm data in terms of a cost-benefit-calculation.

The main basis for the evaluation model is a status quo analysis of individual animals, their different courses of lactation and their days-on-farm. From this, model parameters can be derived for describing lactation curves and physiological interrelations. The model and its formulas and algorithms allow a comprehensive quantitative and qualitative imaging of the basic functioning of a dairy herd considering significant cause-effect correlations. For the analysis of profitability, results of single lactations of all cows are converted to a standardized 365 days dimension and an average herd size. Additionally, influences of diseases and production methods on the farm profit are estimated. Different variations of the calculation procedures (using the predefined mathematical model) allow an estimation of the impact of changes in important factors (e.g. milk price, feedings

costs, culling rate, days in milk) on the development of the herd and its productivity and thus on the profitability.

The “Profitability Analysis Cow” is currently a prototype based on Microsoft EXCEL. “Profitability Analysis Cow” will be finished and available as software in the course of 2016. A simplified version (for Microsoft Windows) for the estimation of farm losses caused by diseases on the basis of uniform calving periods has already been developed.

For the test-phase, the Toolbox will contain the results of the profitability assessment, provided by Data Service Paretz Ltd, for each farm.

The profitability assessment provides a different economic perspective on the dairy herd. It aims to contrast sub-groups of a herd (e.g. culled animals) concerning their contribution to the operating results. According to performance data, a model based on lactation numbers and cow years is built (Table 1). Within the lactations cows (and their individual performance data) which completed the lactation and are currently lactating are distinguished from cows that have been culled during the time of analysis, thereby forming two sub-groups. Also other subgroups, like cows with a specific diagnosis, can be created, given that the data are available in the herd management software.

Table 1: Herd figures by lactation

total	Oberserved values							
Lactation	L1	L2	L3	L4	L5	L6	ab L7	gesamt
Lactations observed	**22**	**19**	**14**	**11**	**5**	**4**	**12**	**87**
Cows analysed (non-culled)	**18**	**17**	**13**	**11**	**5**	**3**	**11**	**78**
Calving interval in days	**414**	367	392	402	365	413	410	395
Dry period in day	**64**	64	67	66	68	69	70	66
Culling rate	**18,2**	**10,5**	**7,1**	**0,0**	**0,0**	**25,0**	**8,3**	**0,1**
Cullings	4	2	1	0	0	1	1	9
Avg. DIM until culling	229	98	150	0	0	143	419	203

Lactations observed	No of observed lactations within the time of analysis. Single animals might occur twice as they are present in the time of analysis within different lactations.
Cows (non-culled)	No. cows within the time of analysis which completed the lactation and are currently lactating
CI	Calving interval
dry period	Days dry
Avg. DIM until culling	Average days in milk of culled cows within time of analysis
Model cows	Estimated no. of animals by no. lactation calculated according to DIM, avg. DIM until culling, CI

Data on costs of dairy production from annual accounts are evenly distributed to the 365 day time period, representing the process costs of dairy production per day. These costs include variable costs as well as annual costs for buildings and machinery, without replacement costs.

To assess the contribution of sub-groups (culled animals and performing cows) to the farm profit and losses, the returns from sold milk are allocated to the sub-groups according to the performance data (milk yield) derived from individual lactation curves. Costs are allocated according to feeding days. The costs for replacement are calculated according to the number of cows that left the herd during the time period. It is assumed that each cow is replaced by a heifer. Thus, replacement costs are accounting for an average earning for a slaughter cow and costs for a new heifer.

The comparison of the contribution of sub-groups to the farm profit (Table 2) provides an insight in losses due to animals leaving the farm earlier than desired, thereby creating awareness and economic potential for improved animal health management.

Table 2: Contribution of culled and non-culled animals to the farm profit

	Annual result					
	total		non-culled		culled	
	per MC	sum	per MC	all	per MC	all
Model cows	49		45		4	
Returns	2.701	131.090	2.602	116.814	3.921	14.276
Cost	2.615	126.888	2.339	104.968	6.020	21.920
Farm profit	87	4.202	264	11.846	-2.099	-7.644
Replacement cost	278	13.500	0	0	3.708	13.500

The profitability assessment for each farm participating in the test-phase is provided as a pdf document in the toolbox.

4.5 Proactive protocols

The proactive protocols, currently under trial in workpackage 3, support herd health monitoring in two stages. The starting point is a regular monitoring of 1st level indicators. If alert levels are exceeded, a more specific monitoring of 2nd level indicators is proposed, leading to possible measures. During the ongoing application of protocols, farmers adjust indicators and alert levels in cooperation with their advisers to their farm specific needs. The final evaluation of indicators is expected for June 2016. So far the proposed 1st level indicators as well as a draft monitoring protocol are available in the toolbox.

4.6 Alternative treatments

An effective use of alternative treatments can only be expected if the remedies itself are effective. At the same time, the diagnostic procedure and the treatment in each individual case of disease have to follow the state-of-the-art. A profound anamnesis and diagnosis are indispensable for the decision whether a homeopathic treatment strategy is appropriate in the very specific case. When trying to treat with homeopathy, it is not only essential to interpret the symptoms and to identify the possible pathological causes but to select the appropriate ‘remedy picture’. People who diagnose and select the appropriate remedy have to be well grounded in physiology and pathology and comprehensively familiar with symptoms, diseases and their causes. These tools are designed to support those who treat diseased animals in finding the appropriate treatment. They will also increase the awareness of the persons in charge regarding the signs of diseases and will reduce the time needed for therapeutic decisions. Correspondingly, suffering of diseased farm animals due to a prolonged phase of an inappropriate treatment is expected to be reduced.

In relation to the different production diseases (mastitis, metabolic and fertility disorders), two supporting tools (decision trees and anamnesis tools) have been elaborated. Decision trees are tools making use of a tree-like graph to determine a course of action, showing the most appropriate treatment strategy. Excluding criteria and important diagnostic steps in form of branches were implemented to lead the user to an appropriate treatment of diseased animals. Anamnesis tools serve as guidance and contain distinctive aspects of anamnesis and diagnosis (e.g. general condition, causa, striking symptoms, modalities, character of the animals etc.) the person in charge should be aware of. Based on this guidance, the final homeopathic remedy can be detected by a standard repertory (e.g. Kent, Synthesis, Radar opus etc.).