Web based communication of farm LCA results to farm managers

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ABSTRACT

Farm level life cycle assessment (LCA) has been recognized as an appropriate farm management tool in order to identify the environmental burden of farming. So far, little attention was directed to the targeted communication of the results to farm managers and further users, such as farm consultants or scientists. However, communication is the key to the understanding of the results by the decision makers and hence to taking actions for improving the environmental impact of farming. This triggered the aim of developing a comprehensible, practical, and user-friendly web based communication tool for environmental management at farm level.

In the design process, experts from linguistics, software engineering, and agricultural research worked closely together. Decision-making and communication patterns established in psychological, linguistic and pedagogic theories were taken into account as well as long-lasting experience in farmer consultancy.

The tool *FarmLife-Report* is structured into three steps of result data communication: i) information about means of production, ii) agronomic key figures, and iii) environmental impacts. For the steps 2 and 3 the result information is structured into three levels of detail: First, an overview level for farm managers. Second, a consultant level addressed at farm advisors providing more details, and third, the complete set of figures and result, i.e. the expert level, directed at scientists. Different types of tables and charts (bar and bubble charts) are used to give a targeted information on the farm results.

FarmLife-Report, the farm LCA communication tool, was applied on a network of 51 farms in Austria. The tool proved to fulfil the expected tasks. The feedback from the applicants was very encouraging. The key to success was to apply a balanced combination of the tool's user-friendliness, its extensive possibilities of analyses, and its targeted communication on different levels of detail. In a further step, the identified weaknesses will be removed and a new version targeting at educational purposes will be developed. At this time, a dairy commissioned the application of *FarmLife-Report* for its milk supplier to offer them environmental consultancy.

Keywords: Knowledge transfer, Decision support, Communication tool, farm consultancy, FarmLife-Report

1. Introduction

Over the last decade, farm life cycle assessment (farm LCA) has been recognized as an appropriate farm management tool to identify the environmental burden of farming. Several efforts were made in the development of tools, methods, emission models, and databases. However, the ultimate challenge is to create a benefit for practitioners by transferring this knowledge to a wide range of farm managers and further users. Communicating environmental management results, e.g. from LCA, and practical advice is complex. Still, communication is the key to the understanding of the results by the decision makers and hence to taking actions for improving the environmental impact of farming. A further complexity arises from the requirement to provide a communication tool empowering the addressee to autonomous use and allowing him to obtain explanations regarding the respective LCA results. This calls for a comprehensible, practical, and user-friendly web based tool.

In the project FarmLife, financed by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW), we aimed at elaborating such a web based communication tool for environmental management at farm level, which is presented in this paper.

2. Designing a knowledge transfer Farm LCA Tool for decision making

The tool *FarmLife-Report* is part of a whole set of farm LCA tools developed within the project FarmLife (Herndl et al., 2016). Its purpose is the communication of farm LCA results to different stakeholders, i.e. farm managers, farm advisors, scientists and further interested parties. When designing the tool, two aspects were at core: integrating knowledge from the fields of communication science and psychology, and using the experience from previous consultancy activities for farm managers. Hence, experts from linguistics, software engineering, and agricultural research closely collaborated for the design. We identified three conditions, which have to be fulfilled in order to facilitate a change of attitude by the farm manager: i) Assurance that all data are correct and the calculation process is performed correctly; ii) a quantitative appraisal of agronomic key figures of the farm; and iii) providing expertise with appropriate information for consultancy. The first is indispensable to build trust in the results. The second allows classifying whether a farm is

comparatively performing on average, well, or not. The third condition displays competency. All of them have to be met to enable emotional amplification, i.e. an inner emotional conviction as a result of further information search and appraisement (Finotti, 2015), by the farm manager of the assessed farm.

As a part of the project FarmLife (Herndl et al., 2016) the study “Life cycle assessment: decision under ambivalence” (Finotti, 2015) explicitly refers to the problems of communication of the results as well as to possibilities of decision support for the farm managers. The study is based on psychological (emotion- and attitude-psychological) (e. g. Hänze, 2002) as well as linguistic (e. g. Grice, 1975) and pedagogic theories, and on findings from the field of knowledge transfer.

Induced by individuality in terms of sociocultural and emotional aspects, the LCA results are likely to be experienced ambivalently by the involved farm managers – especially, if a decision on further farm management is to be made. As far as it is no routine decision, each decision does not only have cognitive (rational) but also emotionally action-guiding background. In many cases, decisions are supported by inner values and attitudes. The latter enable humans to have a stable and structured view of the world. If the option of an action (operation) includes positive as well as negative aspects, this will be experienced as being rather aversive, i.e. according to Hänze (2002) emotionally threatening, and emotionally incriminatory. Conditioned by character, humans deal differently with this ambivalence. Mostly, we try to build up a structure of dominance in order to develop polarised emotions, based on which we are able to make a decision and become capable of acting, i.e. decision under ambivalence. Hänze (2002) argues for an automatic processing of emotional polarising and amplification, which is always repeated until somebody is capable to make a decision (Figure 1). Emotional amplification combines provision of information on a problem as well as estimation of utility, and probability of different consequences of actions, the search for social strengthening and emotional imagination or mental simulation of possible consequences of a decision.

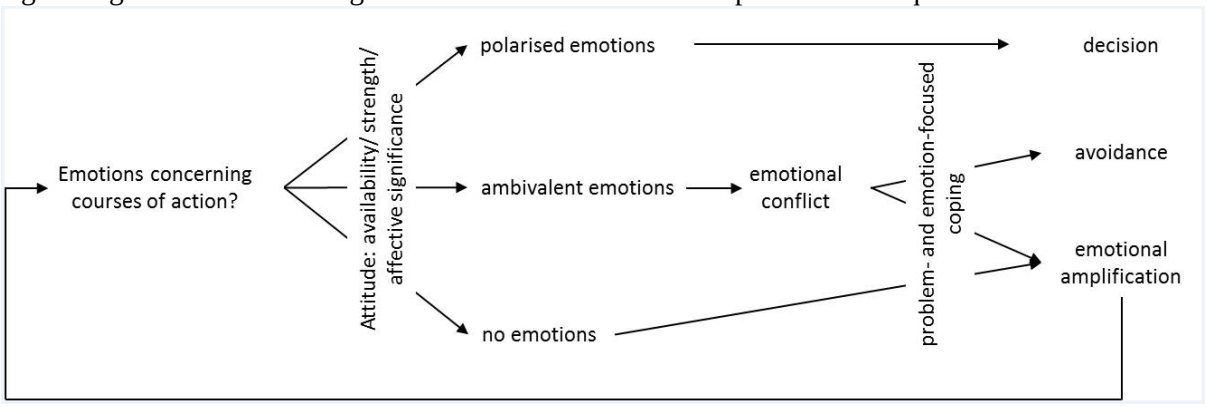

Figure 1: Simplified diagram of the integrative frame-model of emotional decision-making according to Hänze (2002).

Of course, the way of knowledge transfer plays an important role in this matter. Knowledge transfer has to be accomplished in a way technically and linguistically accommodated to the customers (e. g. Wichter und Antos, 2001; Busch und Stenschke, 2004). Strategies, which are able to produce action-guiding emotions, function in a supporting way. In order to implement a successful knowledge transfer to the farm managers with respect to their individual results, we developed a concept for farm consultancy both in terms of knowledge transfer and of a more conscious communication, based on the abovementioned facts and theories.

The concept enabled us to provide commonly used agronomic key figures and options of action, and to connect them to environmental impacts. This combination allows practical recommendations for farm-internal optimisation as well as outward-directed communication of the environmental performance. Previous experience showed that environmental impacts are still novel key figures, which are better understood by farm managers in a bottom-up strategy. For example, the amount of fertilizers and the nitrogen balance of a field have to be addressed before discussing eutrophication.

In addition to autonomous use of the web based tool *FarmLife-Report*, consulting can be performed in workshops with the help of the same tool. Still, a direct and personal consulting in combination with *FarmLife-Report* is recommended. Thus, it is easier to consider individual aspects,

and communication can be better adapted to needs of the farm manager helping to support actions on the farm.

3. Structure of the communication tool *FarmLife-Report*

The tool *FarmLife-Report* has three steps of presenting data and results (Figure 2):
The first step addresses the means of production and offers an overview of the farm characteristics.

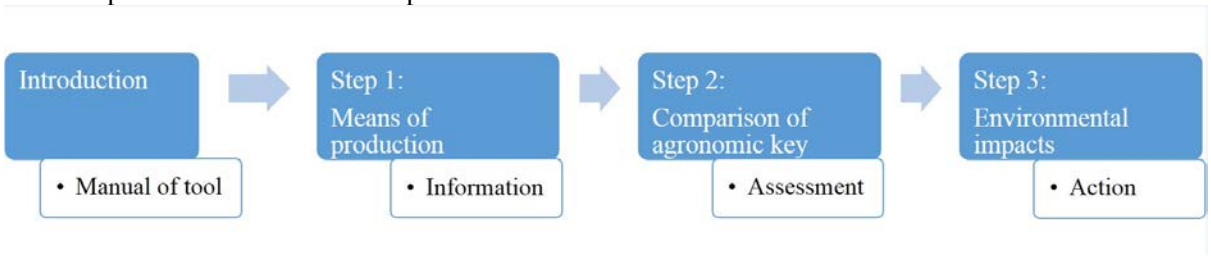

Figure 2: Three steps of presenting data and results for farm LCA communication

The second step provides a comparison of agronomic key figures of a group of farms, allowing an appraisal of the assessed farm. The key figures are depicted with bar and bubble charts. The bar charts are divided into quartiles with the first quartile and the fourth quartile representing the favourable and unfavourable situation, respectively. The bubble charts are split empirically into four sections (Figure 3): These sections give a first classification of the assessed farm. This classification is performed using six key indicators, i.e. non-renewable cumulative energy demand (nrCED, ecoinvent, Hischier et al., 2010), global warming potential (GWP, IPCC 2007), aquatic eutrophication with nitrogen and phosphorus (EDIP03, Hauschild & Potting 2005), total nitrogen fertilization on farm, and direct-cost-free output. For each of the four farm classes, there is a basic message: For the extensive farms (i.e. moderate input use) it is: "Continue acting with moderate use of inputs on your entire farm, including labour time." For efficient farms: "Pay attention that the efficiency is not depleting the natural resources of your farm. Nutrient balances in the soil and the organic matter content have to be considered in the long term." Inefficient farm: "Try to corner the challenges and search for assistance". Intensive farms: "Take management decisions on your farm with regard to its environmental impacts." In step 2 hyperlinks are provided, leading to further consultancy documents.

The third step comprises environmental impacts and options for action suitable for the assessed farm. At this level, *FarmLife-Report* depicts the environmental impacts related to so-called "input groups". Input groups are a scheme, where all resources, means of production, and direct emissions of the farm are grouped thematically. They are: 'Buildings and equipment, 'Machinery', 'Energy carriers', 'Fertilisers and field emissions', 'Pesticides', 'Purchased seeds', 'Feedstuffs, concentrates (purchased)', 'Feedstuffs, roughage (purchased)', 'Purchased animals', 'Animal husbandry', and 'Other inputs'. This allows identifying the main contributors to each environmental impact.

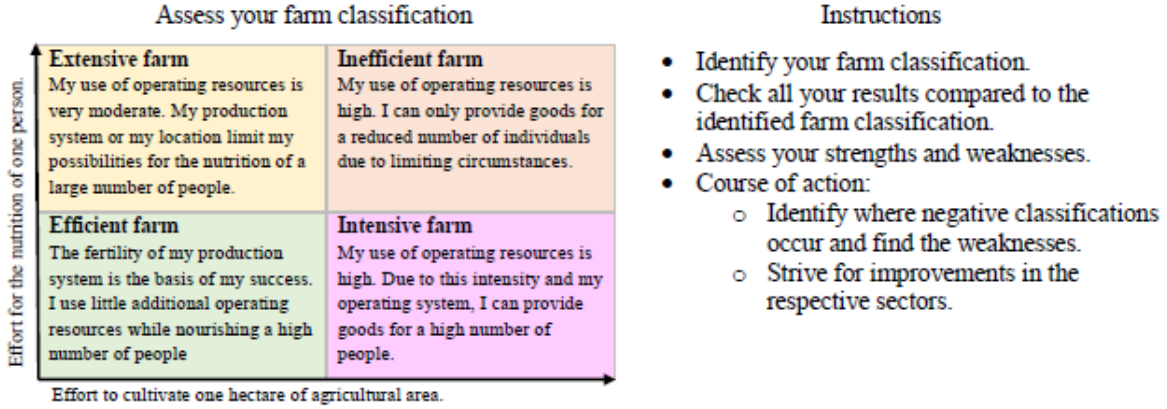

Figure 3: Classification of farms into four farm classes.

Within step 2, i.e. comparison of agronomic key figures, and step 3, i.e. environmental impacts, *FarmLife-Report* provides three levels of expertise: i) An overview level, addressed at inexperienced appliers of environmental management, comprising the most important figures and results (Table 1). The indicators are reduced to the core information, necessary to build up knowledge and understanding. These indicators are interlinked and should be understood without assistance from a farm consultant. ii) A level for farm advisory services offering a larger number of figures and results as well as information for argumentation, which shall support the farm consultant in his work. iii) An expert level providing the most detailed level of figures and results, i.e. 139 agronomic key figures and 37 impact categories. This level allows in-depth analyses of environmental impacts and addresses environmental scientists.

Table 1: The three levels of expertise and the amount of available data in each of them, referred to different areas of interest.

	Step 2: Agronomic key figures			**Step 3: Environmental impacts**		
	Overview	**Consultant**	**Expert**	**Overview**	**Consultant**	**Expert**
Resources	13	23	54	4	10	14
Nutrients	20	46	70	2	3	8
Pollutant				2	6	15
Economy	6	11	15			

The environmental impacts are given for two functional units, i.e. the livelihood preservation function, which is expressed per hectare utilized agricultural area (UAA), and the productive function, which is expressed per nourished person, i.e. according to FAO (2001) 3879 megajoule digestible energy. The LCA is performed according to the SALCA methodology (Nemecek et al., 2010) using SimaPro 7.3 for computing life cycle impact assessment results (PRé Consultants, Amersfoot, The Netherlands). The life cycle inventories employed in this study originate from the ecoinvent data base v2.2 (ecoinvent Centre, 2010) and from the SALCA database (Nemecek & Kägi, 2007).

4. Application on a farm network and acceptance of users

In the frame of the project FarmLife the set of farm LCA tools “FarmLife” including the analysis and communication tool *FarmLife-Report* were applied on a network of 51 farms in Austria (Bystricky et al., 2015). Four farm types were assessed with the tool: arable farms, dairy farms, fattening farms (pigs and cattle), and wine-growing farms.

An example of figures of results of all three steps is given below for a dairy farm. Figure 4 depicts figures on means of production and agronomic key figures within the farm network for fertilization. The comparison shows that the assessed farm has a comparatively high fertilization rate per ha compared to the other dairy farms of the network.

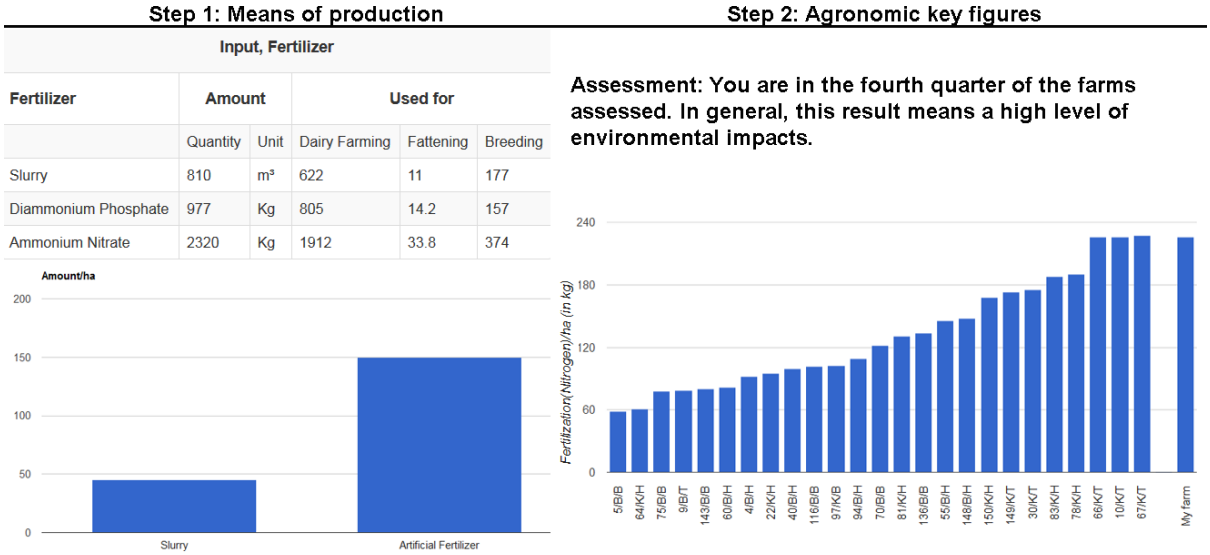

Figure 4: Key figures on fertilization of the assessed farm (Step 1: means of production) and comparison within the network of farms (Step 2: Agronomic key figures). The assessed farm is at the right end of the graph.

The bubble chart (Figure 5) indicates the result of the assessed dairy farm (red dot) compared to the other dairy farms in the Austrian network for GWP and both functional units, i.e. per ha utilized agricultural area as well as per nourished person. According to farm classification, the assessed farm is considered an intensive farm.

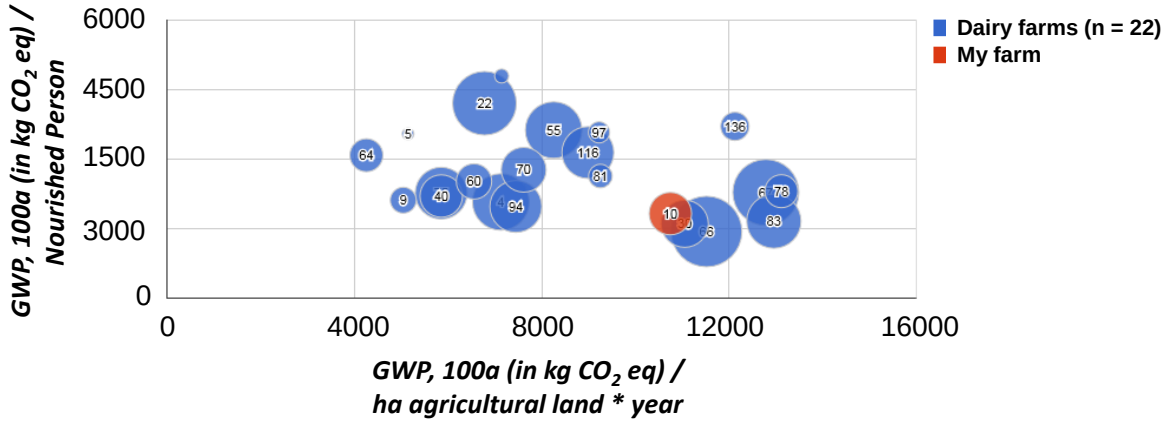

Figure 5: Bubble chart illustrating the global warming potential, 100 years (GWP) of an analysed dairy farm (red dot) in comparison with 21 other dairy farms. The size of the bubbles indicates the total GWP of the farm (without reference to the functional units). The numbers in the bubbles are the farm identification number

In order to be able to derive mitigation options for environmental impacts, a contribution analysis is performed with the help of results of each input group. In Figure 6, the contribution analysis is given for the GWP of the exemplary dairy farm. The areas of possible actions are ‘Animal husbandry’, ‘Concentrates, purchased’, and ‘Fertilizers and field emissions’.

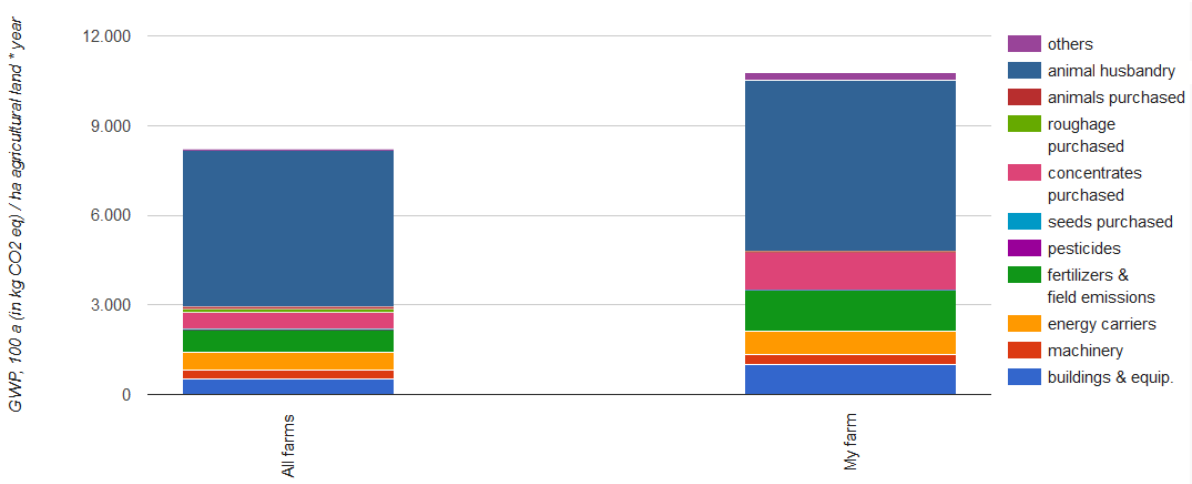

Figure 6: Contribution analysis: Global Warming Potential, 100 years (GWP in kg CO2 / ha UAA) of an analysed dairy farm. The mean for all farms is shown in the left bar, the results for the analysed farm is shown in the right bar. Depicted is the contribution of the different input groups.

An important lesson we learned in the application of the tool and in exchange with the farm managers was not to confront them with too many details at the beginning. What proved to be more constructive was showing them straight away the strengths and challenges of their farm. Later on, insights that are more detailed are desired and must therefore be ready-to-use to underline the findings in a counselling interview.

Overall, the communication tool was very well received by farm managers as well as farm consultants. It was highlighted that *FarmLife-Report* had a clear structure, had informative text elements, allowed flexibility when choosing the reference farms, and excelled at user-friendliness. However, some weaknesses were detected: For example it became apparent that new users of *FarmLife-Report* need assistance to utilise the whole potential of the tool. Despite the clear structure, the amount of data and information was overstraining for some users. Furthermore, the empirical approach for classifying the assessed farms worked well, but needs reconsideration on a scientific basis. We plan to eliminate those weaknesses in the coming months.

This first series of application triggered interest from further stakeholders. A private holding of the dairy sector is currently involved in applying the farm LCA tool, including the analyses and report functions, on its supplying dairy farms, offering them analyses and extension services on a voluntary basis. Furthermore, educational institutes, such as agricultural high schools or the Austrian University College for Agrarian and Environmental Pedagogy, showed their interest. Hence, plans exist to develop a version of *FarmLife-Report* for the use in agricultural education.

5. Conclusions and outlook

We conclude that with the development of *FarmLife-Report* alongside with the entire set of the FarmLife-Tools, we were able to reach the aim of offering the farm manager and his advisor a strongly integrated tool that covers data collection, calculations, assessment, and communication. The key to success was to apply a balanced combination of the tool's user-friendliness, its extensive possibilities of analyses, and its communication on three different levels of detail addressing different target groups (e.g. farmers, advisors, and scientists). This was achieved with the support of communication sciences, which were integrated in the design process, combined with experience in farm consultancy and expertise in tool programming. We identified three conditions, which have to be fulfilled in order to facilitate a change of attitude by the farm manager: i) Ensuring the correctness and plausibility of input data and LCA results; ii) a quantitative appraisal of agronomic key figures; and iii) providing expertise with appropriate information for consultancy.

However, an important lesson we learned was not to confront the farm manager with too many details at the beginning, but straight away show the strengths and challenges of his farm. Hence, the

structure of the communication tool, including three steps of presenting data and results for farm LCA communication as well as the three levels of expertise, proved to be expedient.

The test on 51 Austrian farms proved to be very successful. It revealed not only the abovementioned strengths of the tool, but also weaknesses. In a next step, those weaknesses shall be eliminated. As new groups of applicants have shown their interest in such a tool, the set of tools including *FarmLife-Report* shall be developed further.

Finally, further collaborations with the public and private sector for applying the farm LCA tool are intended.

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