Social and Technological Transformation of Farming Systems:

Diverging and Converging Pathways

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Workshop 2.6: Management of interdisciplinary research processes

Convenors: Thomas Aenis and Bettina König

Farming Systems Research is usually implementation-oriented; it intends to go beyond the pure generation of knowledge and bring concepts and results into practical use. More and more it is organised in the form of transdisciplinary research teams in which scientists of various disciplines, together with practitioners or stakeholders, try to jointly generate and implement solutions for complex real-world problems. Integration is a key issue on different levels: integration of members from science and practice in small teams, integration of concepts and theories to build up a joint understanding of the situation, coherent knowledge production and integration of results in order to create sustainable systems development. The workshop provided a forum for conceptual discussions and the exchange of experiences with a focus on methods and methodology: methods that support participatory planning of knowledge generation and integration, implementation, monitoring and evaluation; that facilitate effective and efficient team work and enable mutual learning processes amongst stakeholders from science and practice, and ways of organising interaction in the often large, geographically dispersed, disciplinary, hierarchical and culturally diverse teams. We thus invited concept papers on interdisciplinarity and transdisciplinarity management in Systems Research as well as case studies. The latter might show best practice, but we also encouraged submissions that showed failures and problems that led to a well-founded, better understanding of roles and functions to be fulfilled by the management in the light of current understandings on ID& TD management – based on the literature, funding bodies, partners involved and stakeholders. During the workshop we planned to identify and discuss cross-cutting issues such as “integration” and “implementation”.

The role of sustainability assessment tools in enhancing dialogue and joint learning in transdisciplinary research on dairy farming

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Abstract: Dairy farming is confronted with a wide range of environmental, economic and social challenges. To address these challenges, a transdisciplinary approach in which researchers and practitioners collaborate is needed. In the AUTOGRASSMILK project, researchers, farmers and farmers' organisations collaborated to address current challenges in European dairy farming. By combining a scientific background with the practical context, the project aimed to develop and implement strategies and technologies to combine grazing and AMS in dairy farms appropriate to the different European regions. An indicator-based sustainability assessment tool was developed to assess the sustainability performance of dairy farms. Results from using the tool on 26 dairy farms in six European countries illustrated current economic challenges in dairy farming. The collaborative development of the tool supported participants to engage in dialogue on what constitutes sustainable dairy farming. Developing the tool improved understanding of regional differences in dairy production, and challenges involved in defining generic strategies and policies to improve sustainability in dairy farming. The development of a sustainability assessment tool involves decisions on sustainability themes, indicators and reference values and brings forward differences in perspectives and values on sustainability. As such, the process of developing a sustainability assessment tool can enhance dialogue and learning in transdisciplinary projects.

Keywords: Sustainability assessment tool, context specificity, automatic milking, international research collaboration, grazing, sustainability indicators

Introduction

Dairy farming represents an important sector in the export of agricultural products from the European Union (EC, 2016). The sector is, however, confronted with a range of environmental, economic and societal challenges. Livestock production is globally responsible for 18% of greenhouse gas emissions and contributes to biodiversity loss and competition for resources such as land, water and phosphorus (Steinfeld et al., 2006). The abolition of the milk quota in the EU in 2015 resulted in an increasingly globalised dairy market and caused economic challenges for dairy farmers such as uncertainty of prices and vulnerability (Jongeneel & van Berkum, 2015). Also societal concerns regarding animal welfare, the use of antibiotics, landscape quality and food safety need to be addressed (Lebacq et al., 2013; Dolman et al., 2014). Sustainable dairy farming should therefore be more environmentally sound, economically viable and socially acceptable.

An increase in the use of automatic milking systems (AMS) and associated decrease in grazing, which is a trend across European dairy farms, has resulted in concerns regarding the sustainability impact (Van den Pol-van Dasselaar et al., 2008). Grazing is considered to enhance the natural behaviour of dairy cows, increase milk quality (Elgersma et al., 2006) and can have an economic benefit (Holshof et al., 2015; Oudshoorn et al., 2015). Combining grazing and AMS on-farm is challenging as it requires a high level of management of the herd and grassland, observation and infrastructure (Oudshoorn & Spörndly, 2013). Farms with large herds in particular are often confronted with long walking distances to the grassland resulting in a decrease in milk yield and higher labour demand (De Koning, 2010). Overcoming the tension between the requirements of AMS and grazing management could offer sustainable solutions, e.g. for animal health and welfare.

Addressing these challenges requires a transdisciplinary approach in which cooperation between researchers and practitioners is established (Baumgärtner et al., 2008; Mobjörk, 2010; Popa et al., 2015). In line with Baumgärtner et al. (2008) we define transdisciplinarity as an approach to *“reach out beyond science and to include aspects of practical contexts and values or normative judgements (sustainability, good-practice), as well as to feed back results into practical actions (politics, management).”* In the AUTOGRASSMILK project, researchers with different scientific backgrounds (i.e. economics, technology, nutrition, grassland management) collaborated with farmers’ organisations and farmers in six European countries to study the challenges involved in combining grazing and AMS on dairy farms. By combining a scientific background with the practical context, the project aimed to develop and implement strategies and technologies to combine grazing and AMS in dairy farms appropriate to the different European regions. As part of the project a sustainability assessment tool was developed to gain insight into the sustainability performance of dairy farms combining grazing and AMS. The outcomes of such a tool could support farmers in their decision making and in addressing sustainability challenges (Pope et al., 2004; Marchand et al., 2014).

Sustainability assessment tools

Over the past decades a wide range of indicator-based sustainability assessment tools have been developed to assess farm-level sustainability (Schader et al., 2014; Marchand et al., 2014). Tools vary in their function, target group, geographical and thematic scope (Schader et al., 2014; Binder et al., 2010). Some tools focus on a specific agricultural sector (e.g. dairy (Meul et al., 2008) or poultry (Pottiez et al., 2012)) whereas other tools are more generic (FAO, 2013; Gasso et al., 2015). Next to the assessment of a farm’s performance on a range of sustainability indicators, sustainability assessment tools can contribute to dissemination and learning on sustainability (Bell & Morse 2008). The adoption of sustainability assessment tools in practice is, however, limited (Triste et al., 2014). Possible reasons for the limited adoption include a mismatch between value judgements of tool developers and users on what is sustainable, as well as budget and time constraints, low user-friendliness and high complexity (de Olde et al., 2016b; De Mey et al., 2011). Involving stakeholders is considered as an important step to include different perspectives on sustainability, and can contribute to a sense of ownership and increase tool adoption (Triste et al., 2014; Bell & Morse 2008). In this paper, we describe the development of the sustainability assessment tool developed in the AUTOGRASSMILK project and reflect on its’ contribution to dialogue and learning in the project and in farming practice.

Development of the tool

The AUTOGRASSMILK project (EU FP7)[1] consisted of a consortium of 15 members and ran from 2013 to 2015. The members included six farmers' organisations, six research institutes and two farmers and a project manager. The members were based in six countries: Belgium, Denmark, France, Ireland, The Netherlands and Sweden. At a later stage, researchers from Luxembourg joined the project. During consortium meetings, representatives of farmers' organisations, farmers, and generally, multiple researchers from each research institute were present representing different disciplines. The project included five work packages including one on sustainability assessment. Tasks related to the sustainability assessment tool were organised through two parallel processes: data collection on monitor farms and the development of the tool (Figure 1).

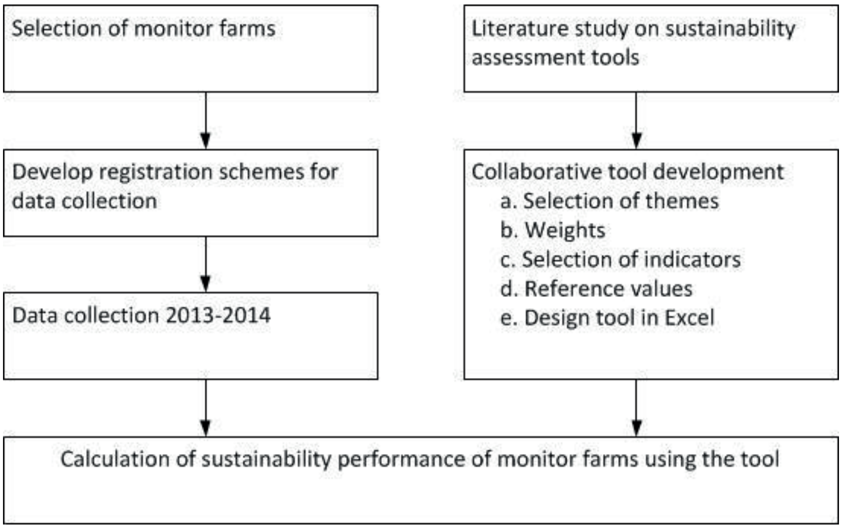

Figure 1. Steps in data collection and tool development in the AUTOGRASSMILK project

In each country monitor farms were selected to collect data on various topics related to the project over a 2-year period (2013-2014). The farms were selected by the farmers' organisations in cooperation with the research institutes, using criteria such as effective integration of grazing and AMS, data capture ability, previous association with recording techniques, foreseen stability of the farm management, and farmers' interest. A total of 37 dairy farms, including 11 organic farms, participated in the project (Table 1). The monitor farms were not representative of the country, because the project could not provide means for the amount of farms needed for representative monitoring. Basic characteristics, economics, mineral balance, social themes and labour registrations were gathered on dairy farms and to be used in different work packages. Registration schemes developed in the Dairyman project[2] formed an inspiration and were supplemented with registrations important for evaluation of automatic milking systems and grazing. The farm data was collected by the farmers' organisations in each country.

[1] *http://autograssmilk.dk/*
[2] *http://www.interregdairyman.eu/en/dairyman.htm*

Table 1. Monitor farms and their average characteristics per country. *(Data are from 2013, except for data for Ireland which are from 2014. Country averages are derived from the European Commission (EC, 2014) and based on 2011).*

	Farms	Organic	Dairy cows	Country average	Hectares monitor farms
BE	3	0	99	56	91
DK	6	4	126	142	202
FR	6	0	79	53	174
IR	7	0	95	62	258
LU	4	1	59	53	181
NL	6	2	104	82	175
SE	5	4	121	62	117

To develop a state of the art sustainability assessment tool, a wide range of sustainability assessment tools were studied (de Olde et al., 2016b). Following the FAO framework for sustainability assessment of food and agriculture systems (SAFA) (FAO, 2013), four sustainability dimensions (economic, environmental, social and governance) were identified to be integrated in the sustainability assessment tool.

The sustainability assessment tool was developed in five steps (Figure 1). During a meeting of the AUTOGRASSMILK consortium, all participants were asked to define four[3] relevant sustainability themes within each dimension. The lists of themes were grouped and resulted in a final list of 25 themes. Next, all participants were asked to distribute 100 points over the themes within each dimension to determine the weight (Table 2). The average weights of nineteen participants are given in Table 2. To assess the performance on each theme, 50 indicators were selected. Selection of indicators was based on literature, expert opinion and data availability. The selection was discussed in open dialogue during two consortium meetings. External experts were consulted to discuss the calculation of economic indicators. To calculate greenhouse gas emissions (GHG) an existing French tool (CAP2er[4]) was selected. This tool is also used to calculate the impact on biodiversity.

After selecting the indicators and calculation methods, reference values had to be defined. For each indicator, a reference value for poor sustainability performance (0 points) and good performance (100 points) had to be selected. Discussions with consortium members highlighted differences between countries on what is considered sustainable. In addition, data analysis of farm data from the monitoring farms demonstrated differences in dairy production systems between countries (e.g. grazing season, production costs and farm income). Researchers in each

[3] *Based on a pragmatic decision to keep the list of themes manageable.*
[4] *http://idele.fr/linstitut-de-lelevage/cap2er/*

Table 2. **Sustainability dimensions, themes and weights, and indicators.** *(The weights are the average weights given by 19 participants. Within each theme, indicators have an equal weight).*

Dimension	Weight	Theme	Indicator
Environmental	31	Nutrients	N Balance, per ha
			P Balance, per ha
			Efficiency N
			Efficiency P
	16	Biodiversity	Number of different crops
			Average paddock size
			N Balance, per ha
			Share of permanent grassland
			Biodiversity score
			Grazing intensity
			Share of land under biodiversity scheme
	13	Water	Water costs per dairy cow
	16	GHG	GHG balance
	23	Energy use	Electricity costs per dairy cow
			Fuel costs per ha of cultivated land
Economic	39	Farm profitability	Farm Net Income per dairy cow
	11	Variable costs per cow	Variable costs per dairy cow
	16	Stability in income	Exposure to price fluctuations
			Dependency on subsidies
	14	Labour	Total labour costs per kg milk
	10	Investments	Costs of invested capital per 100 kg FPCM
			Costs of invested capital per labour unit (hour)
	5	Production costs	Production costs per kg milk
	6	Debt	Interest paid per kg milk
Social	18	Animal welfare	Days outside
			Health costs per cow
			Replacement rate
	19	Working hours	Hours worked per week
			Overworked
	18	Work quality	Physical hardness
			Exposure to hazardous material
			Atmosphere on farm
	11	Image and participation	Score governance aspect 1 to 3
			PR
	12	Farm continuity	Expectancy next decade
			Successor
			Satisfaction with income level
			Survival
	14	Work - life balance	Work life balance
			Free Time
			Holiday Days
	7	Product Quality	SCC average winter and summer
			Grazing

Governance	15	Relation and participation in community	Regional acceptation
	17	Corporate Social Responsibility	Farm visits
	17	Relation & cooperation farmers	Relation to other farmers
	26	Education and skilled staff	Training days
	14	Use of consultancy and advice	Use of advisory service (crops, dairy)
	10	Diversification & openness farm	Agri-environmental payments
			Biogas and / or solar energy Tourism

country were, therefore, asked to provide regional reference values for 27 indicators, to allow a context specific sustainability assessment (Appendix 1). This was considered a challenging and even arbitrary task by the researchers involved as defining what is poor and good sustainability performance is rather subjective, disputable and dependent on factors including context, knowledge, norms and values. To give some guidelines on how to define the references values, values of the worst 25% quantile and the best 25% quantile of farms in their country were used as a starting point. In Ireland, Sweden and Denmark farming organisations were actively involved in defining these reference values. In addition, legal standards and scientific literature was consulted to define reference values. The reference values show a wide diversity between countries on what is considered sustainable performance, as illustrated in Figure 2 and 3. What is considered good sustainability performance in one country can be considered poor sustainability performance in another (Figure 3). For 23 indicators, the reference values were fixed as there is a general understanding on what is considered good or bad for sustainability (e.g. having a successor or not, or having a good or poor relationship with neighbours).

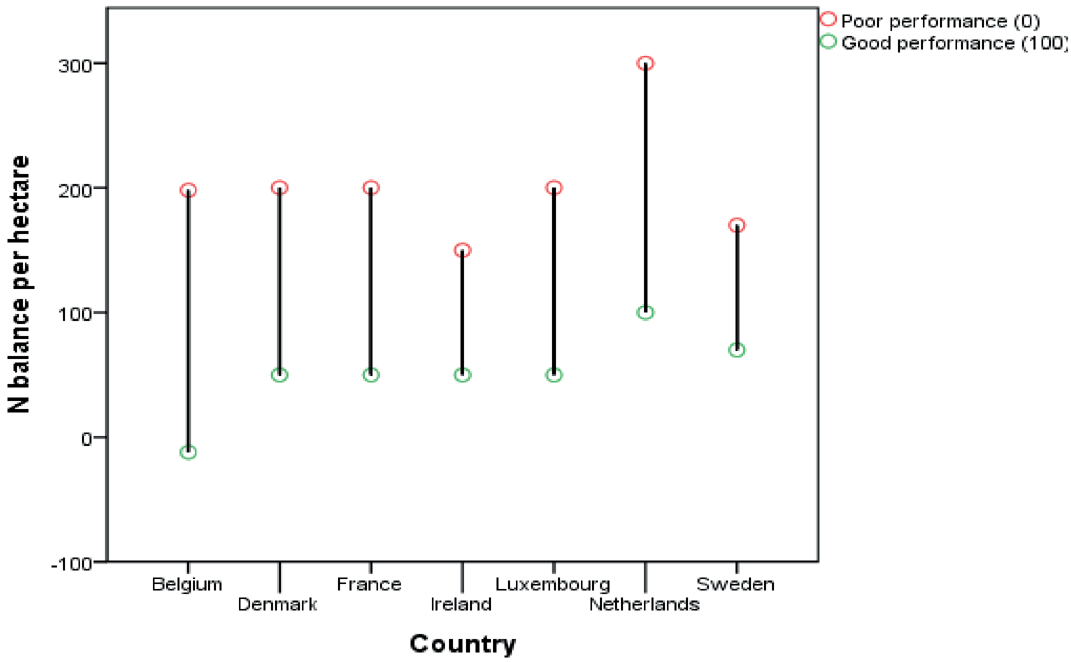

Figure 2. Country-specific reference values for a sustainable nitrogen balance per hectare. *(Poor sustainability performance has a range from 150 to 300 kg N while the reference values for good sustainability performance range from -12 to 100 kg N per hectare).*

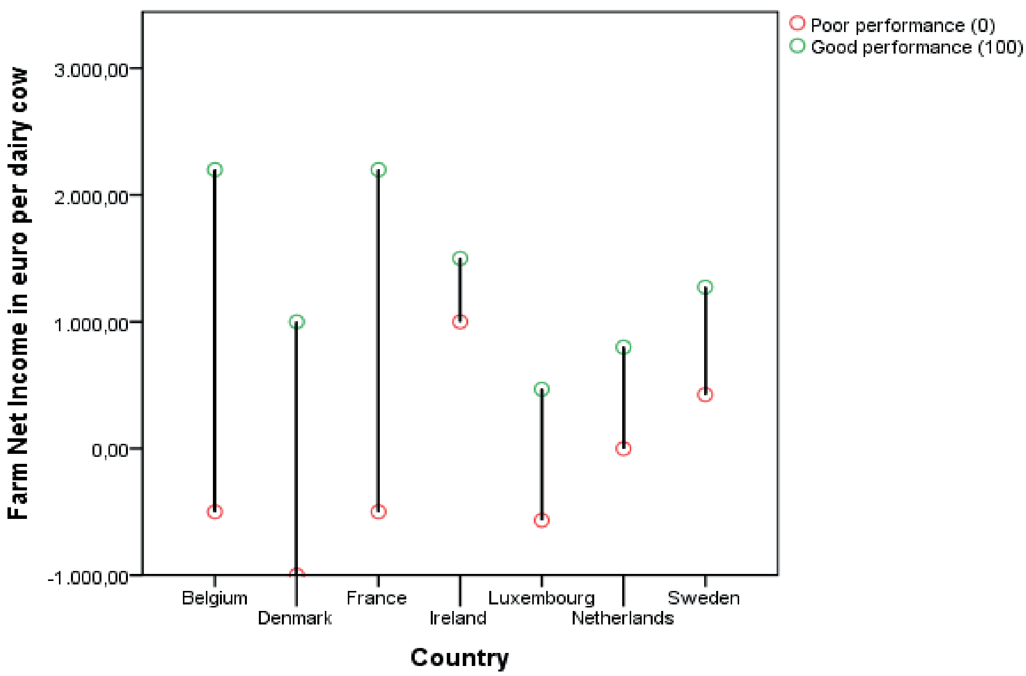

Figure 3. Country-specific reference values for a sustainable Farm Net Income, in euro per dairy cow. *(Poor sustainability performance has a range from € -1000 to 1000 while the reference values for good sustainability performance range from € 468 to 2200 per dairy cow).*

Selected themes, indicators, weights and reference values were combined in an Excel-based tool to compute the sustainability performance of the monitor farms. The tool is available online at http://autograssmilk.dk/results/ under work package 3. By filling-in various Excel sheets, a farmer can calculate the sustainability performance of the farm. A farmer can select reference values of his or her country and compare it to reference values of other countries. In addition, a farmer can develop their own reference values or change the weights of themes in line with his or her perspective on sustainability.

During the final AUTOGRASSMILK meeting, feedback on the tool was gathered. Overall, the tool was perceived as valuable to discuss sustainability at farm-level. In other words, it functions as a discussion-support tool. Integrating a wide range of sustainability themes into a tool to operationalise the concept of sustainability was perceived positively: *"It is good to see how a difficult topic becomes more concrete."* Developing the tool highlighted differences between dairy production systems in the seven European countries as well as differences in what indicators are used and how they are measured. Especially differences between reference values showed the variation in what is considered sustainable. Several researchers involved in determining reference values expressed discomfort with giving weights to sustainability themes and defining what is good or bad for sustainability. One of the researchers stated "*the numbers* [eds. reference values] *are relatively arbitrary."* Reference values were therefore an important topic of discussion during consortium meetings. Explanation of the selected reference values by the involved researchers and farming organisations, gave insight into differences in farming systems between the countries as well as differences in perceptions on sustainable practice. Another researcher stated: *"The reference values on, for example, the number of days the cows are outside* [eds. good performance is up to 300 days in France and 180 days in Sweden] *make you aware of the differences in farming systems and the difficulty of defining generic policies on such topics"*.

Tool outcomes

Sustainability performance of monitor farms per country was calculated by entering the collected data of monitor farms in the tool and using the reference values per country. In this way the sustainability performance per country was calculated according to what experts in the countries had defined as sustainable. Figure 4 shows the average sustainability performance on four sustainability dimensions, based on 2013 data from monitor farms with complete datasets (n = 26). The performance on the economic dimension is lowest of all dimensions for all six countries. Figures 5 – 8 show sustainability performance at theme level.

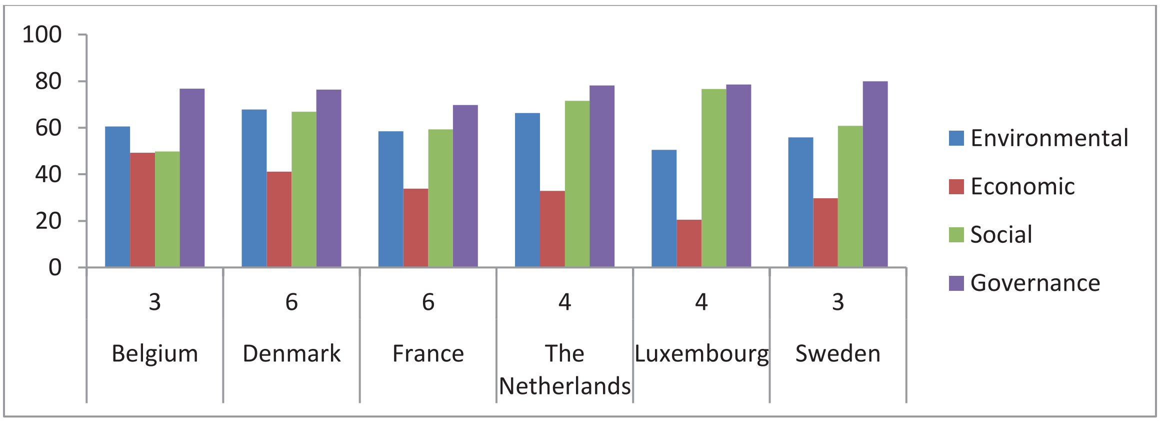

Figure 4. Average sustainability performance of monitor farms in each country based on country-specific reference values. *(A high performance would receive 100 points and a poor sustainability performance 0 points. The number of monitor farms is mentioned together with the country).*

Tool outcomes on environmental themes are given in Figure 5. Scores on greenhouse gas emissions and energy use vary most between countries whereas biodiversity scores relatively low in all countries.

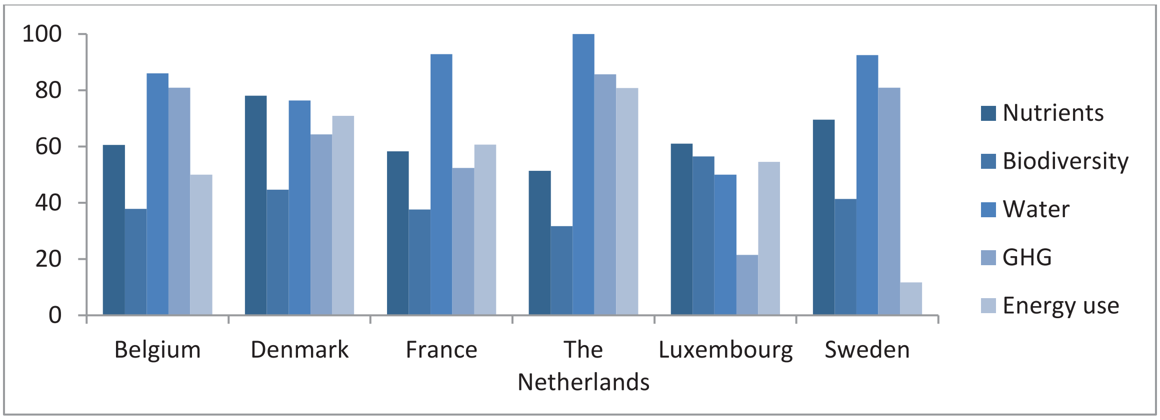

Figure 5. Average sustainability performance on environmental themes of monitor farms in each country based on country-specific reference values.

The average performance of monitor farms on economic themes is given in Figure 6 and shows a large variation on all themes between countries. Even though most countries had accepted a negative Farm Net Income in their reference values, the 2013 results are poor. Farm profitability is low in all six countries ranging from 36 in Denmark to 0 in the Netherlands, Luxembourg and Sweden. A low farm profitability, high variable costs and high labour costs are important factors contributing to a low economic performance of monitor farms in Luxembourg, as observed in Figure 4.

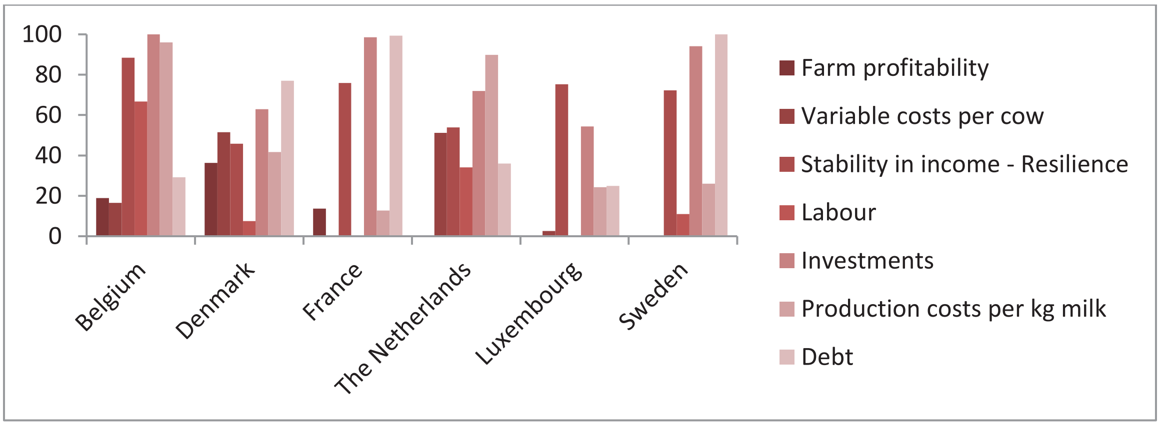

Figure 6. Average sustainability performance on economic themes of monitor farms in each country based on country-specific reference values.

On the social dimension, scores on the theme 'working hours' were low in most countries due to a relatively high number of hours worked per week and a self-evaluation on the indicator overworked. Total evaluation on the social dimension scores was positive, although with variation between the countries (Figure 7). Scores on animal welfare based on the average score on three indicators (days outside, health costs and replacement rate) shows the highest variation between countries.

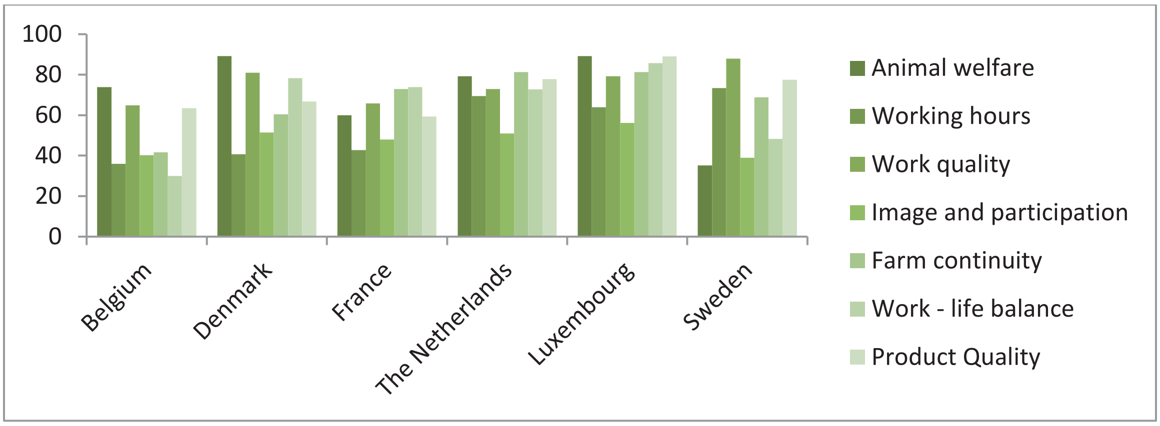

Figure 7. Average sustainability performance on social themes of monitor farms in each country based on country-specific reference values.

Governance themes show a relatively high performance and less variation between countries. This can be related to the use of fixed reference values in governance related indicators, instead of country-specific reference values. Scores on the theme 'diversification and openness of the farm' varies most between countries.

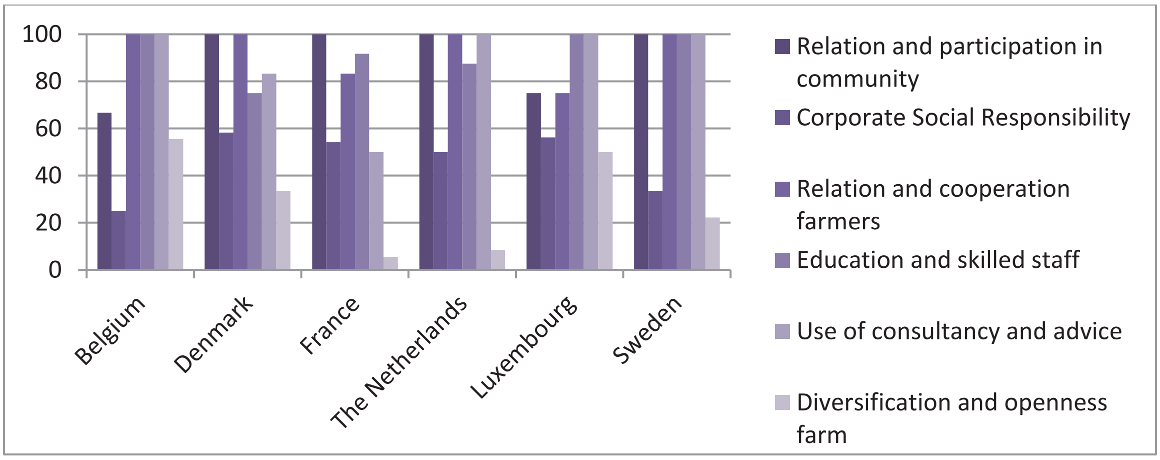

Figure 8. Average sustainability performance on governance themes of monitor farms in each country based on country-specific reference values.

Discussion and Conclusion

The tool outcomes give insight into the strengths and weaknesses in the sustainability performance of monitor farms in six European countries. In line with current developments in the dairy sector, the tool shows that economy presents a major sustainability challenge in dairy farming, even though reference values vary largely between countries. Although the outcomes presented are computed on expert-based reference values, a farmer can also define his own weights and reference values in the tool. This allows a context-specific tool and involves the values and perspectives of the user, which is considered important for the implementation of assessment results (de Olde et al., 2016b; Gasso et al., 2015; Gasparatos & Scolobig, 2012). The tool presents a framework of sustainability themes and indicators in which the user can try out different options and learn more about the differences between countries. The tool can thereby contribute to farmer' awareness and learning on what sustainability at farm-level entails (i.e. themes and indicators), differences between seven European countries (i.e. reference values) and how sustainability assessment tools work and can contribute to decision-making at farm-level. This is, however, a potential contribution to learning which is highly dependent on the adoption of the tool in practice. So far, learning and dialogue mainly took place within the project.

The development of a tool has been valuable in the AUTOGRASSMILK project to support discussions among consortium members on sustainable development in dairy farming. More specifically, by developing a tool we discussed what are relevant sustainability themes, indicators and calculation methods. These discussions gave insight into different traditions, perspectives and value judgements between countries and disciplines on what is important in sustainable dairy farming. Through these discussions consortium members learned more about: 1) strengths and weaknesses of sustainability assessment tools; 2) the selection of sustainability themes, indicators and reference values; and 3) differences between dairy farming systems. In the selection of sustainability themes, for example, we introduced the relatively new dimension "governance" (in line with SAFA (FAO, 2013)), which we first explained before the consortium members defined relevant themes within this dimension. We discussed the role of governance related themes in dairy farming (e.g. participation, management plans and audits) and the difference to the social dimension. Another example of learning relates to the differences in reference values which made the consortium members aware of differences between farming systems (e.g. on days outside as mentioned previously).

The development of the tool integrated different perspectives on relevant sustainability themes from all projects participants (i.e. researchers, farmers' organisations and farmers). Decisions on indicators, calculation procedures and reference values were, however, made in a more top-down approach by the researchers and/or farmers organisations involved. During consortium meetings we discussed the decisions made with all participants to ensure understanding and acceptance of our approach. The tool, nevertheless, echoes the frame of reference (knowledge, values, norms, interest and convictions) of those involved in the project (Te Velde et al., 2002). As a result, the outcomes of the tool frame the sustainability performance of a farm according to what we as tool developers considered important (Gasparatos, 2010)[5]. Decisions made in the development of the tool (e.g. selection of themes, indicators, weights and reference values) therefore need to be transparent to the user of a sustainability assessment tool. Such transparency can contribute to the reliability and relevance of sustainability assessment tools (de Olde et al., 2016a).

Dealing with a plurality of values and perspectives lies at the core of transdisciplinary research (Popa et al., 2015). Developing a sustainability assessment tool requires dialogue between participants on e.g. what is sustainability, what are relevant themes, indicators and reference values. Such dialogue gives insight into differences in the values, assumptions and priorities of participants and can enhance acceptance of diverse value judgements. Our experiences with developing a tool in the AUTOGRASSMILK project shows that the development of a sustainability assessment tool can support dialogue and learning about sustainability and can contribute to addressing transdisciplinary challenges.

[5] *This is also explained to the tool users and is the reason why we made the tool flexible (i.e. possibility to define your own reference values and change the weights).*

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References

Baumgärtner, S., Becker, C., Frank, K., Müller, B., & Quaas, M. (2008). Relating the philosophy and practice of ecological economics: the role of concepts, models and case studies in inter-and transdisciplinary sustainability research. Ecological Economics 67(3): 384-393.

Bell, S., & Morse, S. (2008). Sustainability indicators: measuring the immeasurable? Earthscan.

Binder, C.R., Feola, G., & Steinberger, J.K. (2010). Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. Environmental Impact Assessment Review 30(2): 71-81.

De Koning, C. (2010). Automatic milking–common practice on dairy farms. In Proceedings of the first North American conference on precision dairy management, pp. 52-67. Toronto, Canada.

De Mey, K., D'Haene, K., Marchand, F., Meul, M., & Lauwers, L. (2011). Learning through stakeholder involvement in the implementation of MOTIFS: an integrated assessment model for sustainable farming in Flanders. International Journal of Agricultural Sustainability 9(2): 350-363.

de Olde, E.M., Moller, H., Marchand, F., McDowell, R.W., MacLeod, C.J., Sautier, M., et al., (2016a). When experts disagree: the need to rethink indicator selection for assessing sustainability of agriculture. [journal article]. Environment, Development and Sustainability 1-16: doi:10.1007/s10668-016-9803-x.

de Olde, E.M., Oudshoorn, F.W., Sørensen, C.A.G., Bokkers, E.A.M., & de Boer, I.J.M. (2016b). Assessing sustainability at farm-level: lessons learned from a comparison of tools in practice. Ecological Indicators 66: 391-404, doi:http://dx.doi.org/10.1016/j.ecolind.2016.01.047.

Dolman, M.A., Sonneveld, M.P.W., Mollenhorst, H., & de Boer, I.J.M. (2014). Benchmarking the economic, environmental and societal performance of Dutch dairy farms aiming at internal recycling of nutrients. Journal of Cleaner Production 73: 245-252.

EC (2014). EU dairy farms report 2013 based on FADN data. Brussels, Belgium: European Commission, Directorate General for Agriculture and Rural Development

EC (2016). Milk and milk products. http://ec.europa.eu/agriculture/milk/index_en.htm. Accessed 11-05-2016 2016.

Elgersma, A., Dijkstra, J., & Tamminga, S. (2006). Fresh Herbage for Dairy Cattle: The Key to a Sustainable Food Chain. Springer.

FAO (2013). Sustainability assessment of food and agriculture systems (SAFA): guidelines, version 3.0. Food and Agricultural Organisation of the United Nations.

Gasparatos, A. (2010). Embedded value systems in sustainability assessment tools and their implications. Journal of Environmental Management 91(8): 1613-1622, doi:http://dx.doi.org/10.1016/j.jenvman.2010.03.014.

Gasparatos, A., & Scolobig, A. (2012). Choosing the most appropriate sustainability assessment tool. Ecological Economics 80(0): 1-7, doi:http://dx.doi.org/10.1016/j.ecolecon.2012.05.005.

Gasso, V., Oudshoorn, F.W., de Olde, E., & Sørensen, C.A.G. (2015). Generic sustainability assessment themes and the role of context: the case of Danish maize for German biogas. Ecological Indicators 49(0): 143-153, doi:http://dx.doi.org/10.1016/j.ecolind.2014.10.008.

Holshof, G., Evers, A., De Haan, M., & Galama, P. (2015). Grazing and difficult circumstances: economic benefits depend on milk price and grazing efficiency. Contract, 19, 10,076.

Jongeneel, R., & van Berkum, S. (2015). What will happen after the EU milk quota system expires in 2015? An assessment of the Dutch dairy sector. In W.U. Lei (Ed.). The Hague: Wageningen UR.

Lebacq, T., Baret, P.V., & Stilmant, D. (2013). Sustainability indicators for livestock farming. A review. Agronomy for Sustainable Development 33(2): 311-327.

Marchand, F., Debruyne, L., Triste, L., Gerrard, C., Padel, S., & Lauwers, L. (2014). Key characteristics for tool choice in indicator-based sustainability assessment at farm level. Ecology and Society 19(3): doi:10.5751/ES-06876-190346.

Meul, M., Passel, S.V., Nevens, F., Dessein, J., Rogge, E., Mulier, A., et al., (2008). MOTIFS: a monitoring tool for integrated farm sustainability. Agronomy for Sustainable Development 28(2): 321-332.

Mobjörk, M. (2010). Consulting versus participatory transdisciplinarity: a refined classification of transdisciplinary research. Futures 42(8): 866-873.

Oudshoorn, F.W., Brocard, V., & Van den Pol-van Dasselaar, A. (2015). Economic impact of grazing dairy cows on farms equipped with an automatic milking system (AMS). Grassland Science in Europe 20: 469-471.

Oudshoorn, F.W., & Spörndly, E. (2013). Operational strategies for optimising grazing when using automatic milking systems in organic dairy production. In: A-K. Løes, M. Askegaard, V. Langer, K. Partanen, S. Pehme, I.S. Rasmussen, E. Salomon, P. Sørensen, K. Ullvén and M. Wivstad (Eds.) Organic Farming Systems as a Driver For Change. NJF Report 9(3) 129-130.

Popa, F., Guillermin, M., & Dedeurwaerdere, T. (2015). A pragmatist approach to transdisciplinarity in sustainability research: from complex systems theory to reflexive science. Futures 65: 45-56. doi:http://dx.doi.org/10.1016/j.futures.2014.02.002.

Pope, J., Annandale, D., & Morrison-Saunders, A. (2004). Conceptualising sustainability assessment. Environmental Impact Assessment Review 24(6): 595-616.

Pottiez, E., Lescoat, P., & Bouvarel, I. (2012). AVIBIO: a method to assess the sustainability of the organic poultry industry. Paper presented at the 10th European International Farming Systems Association (IFSA) Symposium. Aarhus, Denmark, 1-4 July 2012.

Schader, C., Grenz, J., Meier, M.S., & Stolze, M. (2014). Scope and precision of sustainability assessment approaches to food systems. Ecology and Society 19(3): doi:10.5751/ES-06866-190342.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & Haan, C. D. (2006). Livestock's long shadow: environmental issues and options: Food and Agriculture Organisation of the United Nations (FAO).

Te Velde, H., Aarts, N., & Van Woerkum, C. (2002). Dealing with ambivalence: farmers' and consumers' perceptions of animal welfare in livestock breeding. Journal of Agricultural and Environmental Ethics 15(2): 203-219, doi:10.1023/A:1015012403331.

Triste, L., Marchand, F., Debruyne, L., Meul, M., & Lauwers, L. (2014). Reflection on the development process of a sustainability assessment tool: learning from a Flemish case. Ecology and Society 19(3): doi:10.5751/ES-06789-190347.

Van den Pol-van Dasselaar, A., Vellinga, T., Johansen, A., & Kennedy, E. (2008). To graze or not to graze, that’s the question. Grassland Science in Europe 13: 706-716.

Appendix 1. Reference values per sustainability indicator, per country (0 = poor performance, 100 = good performance

	BE		DK		FR		IR		LU		NL		SE	
	0	100	0	100	0	100	0	100	0	100	0	100	0	100
N Balance, per ha	198	-12	200	50	200	50	150	50	200	50	300	100	170	70
P Balance, per ha	37	-5	20	5	20	5	5	0	20	5	-20	25	11	3
Efficiency N	13	38.3	10	40	10	40	25	40	10	40	30	65	20	60
Efficiency P	11	32	10	40	30	90	80	100	10	40	80	95	10	40
Number of different crops	1	6	2	5	2	5	0	1	1	6	2	5	2	4
Average paddock size	6	0.8	8	2	6	2	2	0.5	4	1	8	2	8	2
Share of permanent grassland	19%	95%	0%	15%	0%	15%	95%	100%	33%	66%	0%	70%	0%	15%
Intensity grazing (cow/ grazed ha)	5.9	0.6	2.5	1	2.5	1	2.5	1.8	7	1	6	2	2.5	1
Land under biodiversity scheme	0%	15%	0%	15%	0%	15%	5%	30%	0%	15%	0%	15%	0%	15%
Water costs per dairy cow	20	1.2	30	15	30	15	7.4	5	60	30	45	25	30	15
Electricity costs per dairy cow	130	50	150	100	150	100	35	27.5	150	100	140	80	127	32
Fuel costs per ha of land	64.82	39.75	100	40	100	40	10	5	100	40	300	100	106	53
Farm Net Income per dairy cow	-500	2200	-1000	1000	-500	2200	1000	1500	-567	468	0	800	425	1274
Variable costs per dairy cow	2258	238	4500	2000	2000	949	550	400	2013	1611	3600	1200	2230	1592
Exposure to price fluctuations	80%	40%	80%	40%	80%	28%	80%	70%	80%	40%	80%	40%	85%	30%
Dependency on subsidies	23%	9%	20%	2%	23%	13%	25%	15%	105%	29%	15%	2%	50%	20%
Total labour costs per kg milk	0.171	0.102	0.1	0.02	0.1	0.02	0.05	0.04	0.12	0.11	0.12	0.04	0.13	0.053
Costs of invested capital per 100 kg FPCM	16.2	7.8	35	2	35	2	45	18	9.1	6.2	25	5	11	2.12
Costs of invested capital per labour unit (hour)	17.78	15.29	50	3	50	3	180	65	8.5	6.2	50	20	159.2	53.1
Production costs per kg milk	0.58	0.31	0.5	0.25	0.5	0.25	0.247	0.22	0.5	0.25	0.5	0.25	0.478	0.318
Interest paid per kg milk	0.022	0.014	0.15	0.05	0.15	0.05	0.01	0.007	0.012	0.007	0.1	0.01	0.849	0.318
Grazing days (days outside)	0	210	0	180	0	250	275	300	0	180	0	180	150	180
Health care costs per cow	110	75	396	174	96	63	75	50	396	174	190	80	97.93	72.3
Culling rate	37	23	40	25	40	25	27	18	40	25	40	20	49	22
Estimated labour hours per week	62	21	50	37	50	37	70	50	50	37	70	40	60	40
Holiday days	0	20	0	21	0	21	7	28	0	21	0	21	0	25
SSC average	334	73	300	100	250	100	225	200	224	194	300	100	355	100

Managing transdisciplinarity: using the situation analysis approach for a joint problem framing

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Abstract: Inter- and transdisciplinary sustainability research aims at generating knowledge to deal with regional and global problems like biodiversity loss. One challenge is the methodological design aligned with the project management fostering the cognitive and social integration of heterogeneous knowledge and actors. We argue that generating a joint understanding of the situation is a necessary precondition for successful knowledge production already in the starting phase. The research project ginkoo develops tools for the management of innovation processes for sustainable land use. It accompanies ongoing innovation processes in two case studies in the Berlin-Brandenburg-area in Germany. One characteristic of the ginkoo project is an intense collaboration with two organisations from the practitioners' side, which develop innovations for sustainable land management. These project partners are the Biosphere Reserve *Spreewald* and the organic farmers' association *"Naturland Marktgesellschaft*". The article describes the transdisciplinary approach of the research project in its starting phase and discusses the approach with respect to methodology, project structure and management, applicability and consequences for the following inter- and transdisciplinary work. The project uses the situation analysis approach as developed by Clarke (2012) for a joint problem framing. A thorough process planning, coordination and documentation of the situation analysis made this approach transparent. The findings of the situation analysis capture the heterogeneity of the situation, including different social and discourse arenas and provide a holistic picture. It provides scientists with in depth insights and guided the reflection of practitioners. As a consequence, the situation analysis assured that the research approach is closely linked to real life problems. Further, it builds a base for disciplinary research approaches as well as the knowledge integration to come in the project.

Keywords: Transdisciplinarity, situation analysis, common problem understanding, sustainable land management, poultry production, marginal wetlands, innovation management

The transdisciplinary research design of the ginkoo project

The project ginkoo deals with sustainability problems of land management from an innovation process research perspective. It asks how the management of innovation processes can be better organised by coordinating actors, such as network managers, regional managers etc. Thereby, it aims at the meso-level that links organisations and individuals in order to generate system solutions. In a pre-phase the project team had developed research questions and the project design in an inter- and transdisciplinary process in three steps[1]: first, practitioners suggested several ideas and innovative projects for sustainable land management and the mixed project team of scientists and practitioners chose two central case studies; second, the

[1] *This work was done in a pre-funded one year phase as part of the project application.*

project team described problems and possible solutions for each case in detail; third, the project team formulated joint research questions and a transdisciplinary project concept (König et al. 2015).

The first case study "*Spreewald*" is located in the Biosphere Reserve Spreewald South-East of Berlin, which is characterised by a typical cultural landscape with a lot of small streams, meadows and little villages with a very diverse park-like appearance and high biodiversity resulting from local grassland management practices. However, this site-specific management is no longer profitable for farmers due to changed regional water governance and is thus threatened by abandonment followed by succession. The maintenance of this cultural landscape therefore requires new forms of management and value added chains. Possible approaches under study are the use of biomass for small-scale thermal production, financing of landscape preservation measures, and involvement of the tourist sector to be linked with each other to a model solution.

The second case study "*Naturland*" takes up the negative externalities resulting from large-scale animal production entities. The Naturland Marktgesellschaft (a trading farmer association within the organic farmers' association Naturland) initiated the regional initiative called "ei care" in 2011 together with a regional wholesaler and farmers. This initiative strives to establish a regional value chain for dual purpose chicken breeds on mixed farms with ethical organic production of meat and eggs. This requires new approaches to link limited production intensity with established value chain infrastructures and logistic routines. The case study explores possibilities for closer co-operation between farmers and consumers.

The six scientific work packages of the ginkoo project cover socio-economic aspects that are relevant for the success of, but often are lacking due to a technology driven management of innovation processes[2]. The project develops, tests, and adopts model solutions for the practitioners' innovations as socially robust solutions for sustainable land management. The ginkoo project chose a transdisciplinary research design in order to contextualise its research. Each scientific work package benefits from the transdisciplinary research design, as the research approach, methods and results can be contextualised, thus allowing delivery of connectivity of knowledge. The intense exchange with practitioners is facilitated by a new funding format, which is called 'transdisciplinary innovation group', funded by the German Ministry of Research and Education. Practitioners are funded as members of the project team and resources for the coordination, facilitation and reflection of the transdisciplinary process are provided.

The paper describes our approach, results and experiences of methodologically guiding, creating and managing the cognitive and social integration in the starting phase of the transdisciplinary project ginkoo.

Challenges for the starting phase of transdisciplinary research

While a commonly shared definition of transdisciplinarity and a "theory of transdisciplinarity" are still lacking, some aspects of research practice have evolved as common ground. Transdisciplinary research aims at co-producing knowledge and at contextualising it in the real

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[2] The scientific work packages cover the topics ex-ante sustainability assessment, acceptance and participation, co-operation and governance, marketing, ex-ante innovation assessment and knowledge management.

world (Scholz et al., 2000; Jahn et al., 2012; Zscheischler & Rogga, 2015). It is especially relevant to deal with complex problems which are characterised by high uncertainty, complex interdependencies, different world views of stakeholders on the problem and no “true” or “false” solution (Fernandes & Simon 1999; Brown et al., 2010, Bergmann et al., 2012). Ideally, transdisciplinary research produces three types of knowledge: system knowledge, target knowledge and action knowledge (CASS/ ProClim, 1997; Hirsch Hadorn et al., 2008), equally addressing relevant societal and scientific questions (Jahn, 2008).

Sustainable land management solutions typically need to address a meso-level between micro decisions of individuals and macro perspectives on sectors, nations etc. This calls for holistic or systemic approaches. Their development requires involving a diversity of elements, actors, differing interests and perspectives, and solution approaches (technological, social, products and services etc.).

Integration can be seen as one of the most important challenges of transdisciplinary endeavours: due to its very nature, such a project has to cope with thematic as well as problem- or product-oriented integration of knowledge and social integration of scientists and practitioners (Bergmann et al., 2012; Scholz et al., 2000). Brinkmann et al. (2015, p. 68) state different transdisciplinary practices have evolved, yet a “best” solution has not yet been identified, also due to missing knowledge about processes and impacts. Zscheischler and Rogga (2015) identify a gap between ambitions, concepts and practices of transdisciplinary research in land use research. The practical insights of the authors and the literature (e.g. Kröger et al., 2012) indicate that often a common problem understanding as an outcome of a joint research process is not addressed explicitly in transdisciplinary processes, rather it evolves implicitly (or not at all).

Defila et al. (2006) distinguish a starting phase after the project preparation phase. They attribute the following tasks to the management in the starting phase - to re-assess aim and scope of the research and harmonise it among each other, to initiate adaptations of budget and team if necessary, to link and to support joint research activities, to determine rules for exchange, to set the frame for the synthesis and commitment for implementation, to define the products, to develop team members’ capabilities, to support social team integration, to create commitment of external stakeholders, to develop a communication concept and create necessary infrastructure, to re-design project organisation and to start processes to assure quality (Defila et al., 2006).

Against this background, amongst others, the ginkoo project faced four challenges for conceptualising and organising its starting phase.

First, inter- and transdisciplinary problem understanding needs to be set up and guided *methodologically*. All involved persons bring in their individual and specific way of looking at the world, which has a strong influence on communication and cognitive integration in the transdisciplinary research team (Defila et al., 2015; Sarkki et al., 2013). We argue that these logics occurring as dichotomies of scientific and practical “expert” knowledge (Thompson-Klein, 2014) have to be mutually understood and partly “overcome” by a common understanding to be able to facilitate integration of results in later stages. Bergmann and Jahn 2008 (p. 92) point out that the starting phase should be designed in a way to be able to integrate and balance ‘‘*contradicting normative scientific and political claims of importance and relevance*”. Only this sub-principle for creating a joint understanding *“ensures that any* *subsequent research task departs from this common reference point and, thus, contributes to the overarching project goal"* (Lang et al., 2012, p.29).

Second, the starting phase is a *social forming process* of an inter- and transdisciplinary team, which is - ideally - able and willing to bring together diverse expertise. Team building is a precondition for commitment to integration. Challenges to team building in transdisciplinary research can be due to e.g. an underrepresentation of relevant actor groups in the project team, conflicts on suitable frameworks and methods or discontinuous attendance (Defila et al., 2006; Lang et al., 2012).

Third, a *common understanding and cognitive integration* has to be achieved and a joint problem framing needs to be developed. We see joint problem understanding (and re-definition) as part of the starting phase. Mogalle (2001) states that both practitioners as well as scientists need to participate in the respective other real-world in order to integrate the different perspectives. Joint understanding has to be generated within the project team as well as with regard to the studied object.

Fourth, this requires a specific *project management* (Defila et al., 2006) that goes beyond purely administrative tasks and guides methodologically an inter- and transdisciplinary process towards a joint problem understanding. Practical, methodical and conceptual knowledge of the management of transdisciplinarity is, however, yet debated, so that integration for joint problem understanding has to be developed for each transdisciplinary cooperation context specifically (Jahn & Schuldt-Baumgart, 2013; Brinkmann, 2015; Bergmann et al., 2012).

Achieving joint problem understanding in transdisciplinary research

Joint understanding is crucial throughout the whole project (Bergmann et al., 2012). Up to now there has not been an established set of methods, which are regularly used to achieve joint problem understanding in transdisciplinary research teams. Bergmann et al. (2012) argue that there is not one "silver bullet". Depending on the type of the problem and the actors involved different methods need to be applied. Inter-, trans- or disciplinary methods can be adapted to facilitate integration (Bergmann et al., 2012). The authors assign the screening of methods as one task to prepare and develop effective methods for integration.

The challenge of all of these approaches is that in the starting phase of inter- and transdisciplinary research a practical decision on how to access the field has to be made. At the same time this decision should be reflected methodologically to prevent the transdisciplinary approach being viewed as "non-scientific".

Methodological considerations

Given the aforementioned, the regular start of the ginkoo project (after the pre-phase) aimed at generating deeper insights into the reframing of the individual research perspectives context specific, a joint reframing and achieving a context specific refined common problem understanding. The project management screened the literature for suitable approaches, which would be open to involving all different perspectives in and on the situation (stakeholders and transdisciplinary team). From among these, actor analysis, network analysis, constellation analysis and situations analysis were considered in more detail. Criteria leading the approach and method selection were the theoretical foundation to later allow for theory development, openness to different disciplinary approaches, differentiated analysis in the case studies, graphical representation to facilitate communication, and openness to situation specific adaptation as well as suitability for inter- and transdisciplinarity. This requires that the method should be applicable in one-day workshops with non-trained participants and be open for different element types that might play a role in the situation.

Against this background, the project management presented the idea to the team and the ginkoo project decided to adopt the *situation analysis approach* (Clarke 2012) for developing a common and holistic problem understanding as a base for its further research. It allowed us to organise a structured process both working in a deductive and inductive mode, thus avoiding a premature theoretical fixation that may predetermine a partial research approach. Clarke asks how the situation analysis could be used in inter- and transdisciplinary research contexts (Clarke, 2012, p. 275).

The situation analysis approach was developed to generate an empirically rich sociological description of a situation based on an extension of grounded theory. Also, in Lewin's extension cycle/ action research process, a situation analysis is an integral part. We used the situation analysis in the sense of what one could call a part of the transdisciplinary action research process. However, the situation analysis approach as described by Clarke (2012), does not depart from Lewin, but from Strauss' Grounded Theory and Foucault. Besides actors and material elements it takes the important role of discourses and social arenas influencing decision-making and action into consideration. By doing so, situation analysis goes beyond the above-mentioned approaches, but was not explicitly developed for inter- and transdisciplinary processes. It involves graphical representations of the situation so that multiple perspectives of the actors within the situation can be made visible for the research team. The constructivist approach of the situation analysis should be seen as a tool box (Clarke, (2012) p. 275).

Within ginkoo the situation analysis was used for starting the transdisciplinary research process, facilitating the team to find a common language. The approach allows building upon different knowledge domains such as scientific theories and practical expertise but also acknowledges that for diverse aspects of the problem framing different perspectives and research approaches are required. Reasons for choosing the situation analyses and adapting it for inter- and transdisciplinary research was (see Clarke (2012), p. 35ff.):

- It provides a methodology which allows involvement of pre-existing knowledge but is also sensitive to the situation under research;
- It addresses a meso-level (in our case studies partly overlapping value networks, touristic destinations, regions, regional knowledge networks, cultural landscape) where solutions for sustainable land management are developed and implemented, also involving discourses and social arenas as structural elements;
- It visualises the situation with different maps, which facilitates communication about a complex ill-structured situation. Therefore, all members of the team and stakeholders are able to participate and their different knowledge can be included;
- It potentially facilitates a common understanding and interpretation of the problems as a continuous process through a context specific transdisciplinary exchange in interviews, workshops, working groups etc;

- Through a stepwise inter- and transdisciplinary development, it can stimulate a reformulation and adaption of individual research designs and fosters a coordinated multi-site-research of interview teams, including different types of data (in our case: maps, visualised discusssion results, interviews, field notes etc.).

Application of situation analysis in the ginkoo-project

The situation analysis was applied in the starting phase of the project and conducted in five steps:

1. The practitioner as project partner and the project management organised kick-off workshops with stakeholders interested in the innovation process at stake for each case study. The moderated workshop invited stakeholders to express their views on the problem and discuss them amongst each other as well as with the researchers. These workshops were documented and the minutes were provided to all participants;
2. Each transdisciplinary workshop with stakeholders was followed by a project-internal transdisciplinary meeting to draw conclusions on the joint understanding and the re-focusing of the research approaches. For each case study the team reframed and specified common research questions and narrowed down empirical topics for a joint research and tool development, thus specifying its research agenda in an intense exchange with the practical project partners;
3. During and after the case study workshops actors for in-depth interviews could be identified. The project team planned a series of nearly 20 expert interviews for each case and prepared a common questionnaire and data management strategy. The interviews were conducted by teams of researchers, which increased not only the understanding of the problem from different perspectives, but also improved mutual interdisciplinary understanding and social team building. The practice partners coordinated the appointments of the interview partners and the different scientists;
4. The practical partners organised excursions for both case studies providing deeper insights into the life world context. Regarding the researchers the excursions deepened their insights in another way than what could be achieved by exchanging ideas in meetings or asking questions in an expert interview. To experience the Spreewald landscape and to get to know chicken keeping in small-scale farms revealed the context of technical, organisational or economic questions and circumstances. But also practitioners benefitted from theoretically led questions from the scientists, which forced them to reflect on their daily routines in another way;
5. Based on this empirical data, the situation in each case was mapped jointly by the team in two groups with regard to the research questions. The team discussed the two maps created for each case study in order to describe and visualise a common understanding. The project management provided an integrated situation analysis with maps visualising this joint problem understanding. These working papers build a common base for specific disciplinary research of the work packages.

Reliability of the process was achieved by a joint design of interview questionnaires, data management rules and carrying out the interviews by at least two members of the project team. Interviews were only conducted on the basis of informed consent. The interviewees had the chance to validate the transcripts, and in some cases interviews were extended because new relevant aspects became obvious to the interviewees through the validation. The knowledge gained via the joint situation analysis was documented in regular feedback rounds. Interviews with the practical project partners on their learning effects were conducted by the coordination team after the completion of this phase.

Results

We present the results with regards to the four previously mentioned challenges of transdisciplinary research.

Methodologically lead starting phase

Applying the situation analysis in the transdisciplinary setting of the ginkoo project involved, after the selection of the approach, a process planning of the starting phase, moderation of transdisciplinary workshops, joint interview survey plan including data infrastructure and interviews within the interdisciplinary team, working groups, organisational meetings, coordination and organisation as well as a documentation of the process. The combination of different methods applied in a coordinated way with alternating individual, interdisciplinary and transdisciplinary process steps, provided both holistic and individually diverse insights to scientists and practitioners. These insights could not have been achieved only via interviews, because they only emerged through transdisciplinary discussions and interdisciplinary reflection. It was, for example, possible to identify joint knowledge needs through the exchange of individual problems and open questions in the *Naturland* case study. The general problem is perceived differently depending on the functions of the stakeholders. The transdisciplinary exchange made additional problems and perspectives visible in both case studies. In the *Spreewald* case study it drew attention to the influence of the history of cooperation and how other systems beyond the studied boundaries, (e.g. global markets, EU politics, and water and energy governance) are specifically impinging upon the focused regional land use problems.

The benefit of this conceptual and methodological approach is made visible through the reframing of the problem description in both case studies.

Social integration

Conducting situation analysis contributed to social team building. Regular project meetings (workshops, working groups, meetings for organisational matters) and visits to practitioners (excursions, workshops, interviews) fostered trust building as a base for open discussions and constructive criticism within the project team. The five transdiciplinary workshops were professionally moderated which enhances trust in the process and established a culture for cooperation. Practical project partners used their reputation to involve additional stakeholders in the project and increased their participation in workshops, interviews and excursions. These measures improved the social relationship between researchers, project practitioners and stakeholders, which resulted amongst other things in open and frank expert interviews where the interviewees openly referred to problems and challenges. Vice versa, documented feedback after workshops shows that transdisciplinary debate also provided new insights for the project practitioners and stakeholders, because questions and composition of participants differed from established communication routines.

Cognitive integration: change of problem perception

For the practice partners, it became obvious and tangible how the different abstract research topics of innovation management were linked to their real life problems in developing their model solutions. They realised that they were related to strategic discussions going on in their work environment. Practice partners used the scientific back-up in a two-step process. First, they used the research perspectives to frame their own work in a conceptual way, achieving an understanding of the big picture. Second, they could focus on the most important problems and crucial issues resulting from this big picture. For instance, it became clearer to practice partners in the *Spreewald* case study, which essential stakeholders had to get on board after the discussion on how and where a model solution should be implemented. These insights were fostered by the researchers' continuous feedback during workshops, excursions or bilateral work meetings. In the case study *Naturland* it led to the eye-opening awareness that so far there is no direct communication to consumers and that this information gap has to be closed by one of the partners in the value chain. What is more, the collection and discussion of open questions led to the identification of knowledge needs and ways to operationalize closing these knowledge gaps.

The process of situation analysis changed the perception of both sides. On the one hand, it guided the scientific reflection about the research topic, the reframing of the common problem understanding as well as the focusing and contextualising of disciplinary research of the work packages. The empirical focus of single work packages shifted, as is obvious from documentation of state of the art of work packages and documented feedback. For instance, the acceptance work package identified that not tourists but land owners and land users should be studied in detail regarding acceptance and participation in the *Spreewald* case study. On the other hand, the perspectives of practical partners changed during the process of joint problem understanding. In the *Naturland* case study the focus shifted from singular egg and meat marketing to integratively communicating both eggs and meat to consumers. In the *Spreewald* case study, the challenge to develop joint aims for cultural landscape preservation and development became tangible. The scientific framing of the real world cases shed new light on the innovation processes and stimulated reflection about the ideas and the design of the innovation processes. Thus, transdisciplinary discussions and the integration exercises provided new insights and ideas for practice partners. The main challenges of managing their specific innovation process and possible ways of dealing with them became clearer. These lessons learned occurred during communication with researchers at workshops and excursions. These opportunities were still there for the practical partners but also, for the stakeholders in the case studies, these occasions became a reference for jointly developed points of view. Practice partners regarded this transdisciplinary communication process as a valuable input to their work. Most issues that arose had economic implications and were directly linked to strategic discussions going on in their field of work. Based on the big picture practice partners could clearly communicate their understanding of the problem to their work environment and initiate problem-solving activities. Practice partners were empowered to deal with crucial issues and overarching problems in their daily practices. Moreover, researchers brought in their neutrality (at least with regard to the practical field) and could ask crucial questions and bring together stakeholders who would not had communicated with each other otherwise.

Two examples will illustrate this change of perception:

In the *Spreewald* case study, practitioners from the Biosphere Reserve have changed considerably the focus of their innovation about preserving and developing further a site-specific and valuable cultural landscape. They started with a bunch of ideas, projects and measures such as an academy for the Spreewald, preservation measures for a highly specific and traditional type of land use for small wetland patches in the preparatory phase. These ideas were vaguely linked via the very broad concept of cultural landscape at the beginning. Different actors were considered as possible partners for cooperation. The situation analysis served the practical partners as a search process using the concept of cultural landscapes as a boundary object. Scientific reframing of the problem and different but coordinated disciplinary and functional perspectives on the challenge to preserve cultural landscape helped to cristallise and prioritise overarching strategic goals and to reassemble projects, ideas, actor groups and financial means into a better aligned strategy. Even though many measures and ideas have been in the air since the beginning of the project they were checked, analysed and matched step by step during the situation analysis process. While the team had initially expected to work on communication and marketing of the innovative solutions, it became obvious that marketing should also play a role in establishing the missing links between agriculture and tourism in the *Spreewald* case study. The empirical data could be used to base the communication on potentially shared, but not explicitly communicated values.

The main change in the perception of the problem of the innovation can be described as a reconfiguration of ideas, concepts, interests and projects by the whole project team. Currently, the quintessence of the innovation is the combination of a new technology using green waste from landscape preservation for small-scale thermal production with landscape preservation measures financed by the Regulations on Intervention under the Federal Nature Conservation Act. This obliges investors to compensate for environmentally harmful interventions and with private sponsoring for landscape preservation measures has the potential to involve tourism as a beneficiary of the cultural landscape.

A telling example of how situation analysis changed perception in the *Naturland* case study about ethical poultry keeping is an initiative of a working group of the research team relaunching the website of the "*ei care*" initiative. In that case, designing the new website served as a boundary object for transdisciplinary exchange joining two very diverse ways of working and thinking. Both sides were not satisfied with the old homepage. The practitioners from the *Naturland* farmer cooperative considered the website predominantly as a marketing tool that was not effective and the researchers were not satisfied with the information about the innovative potential of keeping dual purpose chicken breeds.

In five sessions over six months the working group relaunched the website completely. After the first sessions one practical partner was puzzled by how slowly the group worked because of very fundamental questions from the researchers. They asked for target groups and marketing strategies whereas the practitioners looked for pictures and texts for the website. During this cooperation the researchers explored the constraints of the *Naturland* farmer cooperative with regard to marketing. Even though the *ei care* initiative comes close to an ideal form of hen keeping in the eyes of the whole project team, the organic farmers' organisation does not want to expose all the advantages of *ei care* in their marketing strategy because they are anxious to "blame" other organic hen producers who use e.g. specialised hybrid breeds with all the externalities linked with it. The working group was able to specify target groups and ways of addressing them via the website. The website could establish a link to logistic challenges arising from the problem of small quantities in that the dates and origins for fresh chicken meat are communicated to consumers. The practice partners stated that even though initially the questions of the researchers were very abstract, the practical value of the results cannot be overestimated. The identification of target groups and the explication of a vision is valuable for the *ei care* initiative even beyond the website.

By motivating the practitioners to formulate their key objectives and the specific qualities of the chicken-breeding project, both sides learnt. The practitioners went through a process of self-assurance through explication of implicit knowledge. The process enabled them to prioritise the most important messages and to agree on them. The working group formulated an explicit vision and mission of the *ei care* initiative.

The continuous reflection of the problem framing and the analysis and interpretation of empirical data during the situation analysis changed the perception and the framing of the object of investigation. For the research team, the complexity of the specific situations and different expectations regarding possible contributions of the research project became obvious and somewhat more practically tangible. Implicit and tacit knowledge of practitioners e.g. on old-boys'-networks was made available for the research process. The identified discourses (e.g. on cultural landscape, ethical animal production) and social arenas and their (missing) interrelations (e.g. between tourism and agriculture in the Spreewald region) helped to identify the need for participation and establishment of new co-ordination mechanisms.

Facilitation of integration by the project management

This complex process and research design requires coordination and management structures that develop, facilitate, and coordinate it (e.g. process planning, moderation, joint interview survey plan including data infrastructure, documentation of the process). The project management continuously involved all partners to provide feedback from workshops and to decide consensually about process details. Consequently, methodologically led and joint process logic was visible for the entire team, providing orientation and allowing project ownership. During the starting phase, all members of the transdisciplinary team gave feedback that the coordination was useful to support their research and that the engagement of the practical project partners to support the field access was perceived very positively. This management structure successfully established the project in the world of science as well as in the everyday world of the practitioners. However, all project partners engaged beyond usual commitment in many exchange formats. In our opinion, it is an advantage that the knowledge integration was closely linked to the project management. After the first integration exercise, the project team re-formulated the aim and stated that it was ambitious to jointly create a special quality of the transdisciplinary process.

Discussion and Conclusion

This section discusses the effects of inter- and transdisciplinary process in the starting phase of the ginkoo project to derive an integrated situation understanding. It served as a jointly developed knowledge basis for disciplinary research strands of the work packages and allowed us to contextualise the research. For the project practitioners the transdisciplinary exchange allowed new insights for incremental improvements of the model solutions. It also partly helped to overcome the challenge of debates among scientists about the most suitable frameworks and methods (Lang et al., 2012), because it provides a theoretically "neutral" basis, upon which each framework and method can be set up and can contribute useful perspectives. The visualisation was a necessary step to generate a level the does not per se belong to science neither to practice partners, allowing communication at eye level.

The transdisciplinary deliberation with a counterpart from a different field and logic of action changes the focus of the research. In disciplinary research there is a strong tendency to deduce research questions from theoretical arguments and to delineate a focused, even narrow, research topic. Whereas the transdisciplinary perspective in ginkoo considered also a theoretical, conceptual and analytical research focus; much more the production of contextualised knowledge that enables practitioners to establish the innovation successfully as would be the case in a research project without practitioners. It becomes obvious that project results not only need to be accepted in the realm of science (by peer review) but also in the practical world. This requires a twofold integration. On the one hand, all disciplinary work packages have to consider an interdisciplinary link-up in order to integrate their findings into a scientific consistent system solution. On the other hand, the work packages strive for a model solution to be implemented in the case studies and this requires pragmatic and socially robust tools and solutions. As a consequence, researchers in the work packages have to keep inter- and transdisciplinary connection (but also the resulting tension) for a very long time, probably until the end of the project.

The project team feels responsible but also informed for producing socially robust model solutions; this attitude was fostered by insights into the challenges of the practitioners, social relationship, and mutual trust generated during the situation analysis. The practical partners on the other side also got an insight into the possibilities, but also the limitations of research, because resources cannot be changed during the project duration. To them also the great challenge for the researchers to develop an integrative approach for the scientific part became obvious. They stated that only personal interaction formats could enable the joint social and cognitive integration as achieved. In particular the moderation was perceived as very useful for a structured collaboration.

The transdisciplinary exchange in working groups and the excursions provided the involved scientists with in depth insights as well as providing an opportunity for generating joint *system knowledge*, reflection and identification of entry points for incremental changes for practitioners (*action knowledge*). The direct interaction formats provided insights into differentiated normative assumptions, e.g. on past and future sustainable cultural landscape in the *Spreewald* case study (*target knowledge*). A thorough process planning, coordination and documentation of the situation analysis made this approach internally transparent and externally explicable. Although the starting phase might usually be perceived by stakeholders primarily as an intensive scientific exercise, our process was implemented in such a way that practical partners and stakeholders could participate in this early phase. All involved actors reported benefits from the transdisciplinary research process and reported implementation of incremental changes, e.g. packaging and labeling of fresh meat in the *Naturland* case study. For scientists as well as for practice partners it became obvious that the depth of understanding could not have been reached without resources for the practical partners, coordination and facilitation. Further, the overall objective of the project, to implement model solutions, would not be realistic without this type of funding.

The mutual learning of practitioners and scientists as described here demonstrates that a transdisciplinary situation analysis differs from an interdisciplinary approach without framing out of the real life context. So we conclude that the inter- and transdisciplinary process applied to generate a joint situation analysis served to establish a good way to access the researched field.

However, we consider our transdisciplinary way of implementing the situation analysis as very time consuming because of many meetings, documentation, joint planning of the research process and reflection on it. This was only possible within this funding scheme, which provides necessary resources especially for the coordination and the practitioners.

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References

Bergmann, M., Jahn, T., Knobloch, T., Krohn, W., Pohl, C., & Schramm, E. (2012). Methods for Transdisciplinary Research. A Primer for Practice. Frankfurt/New York: Campus Verlag.

Bergmann, M., & Jahn, T. (2008). CITY:*mobil*: A Model for Integration in Sustainability Research. In: G. Hirsch Hadorn et al. (Eds.) Handbook of Transdisciplinary Research pp. 89-102. Dordrecht: Springer.

Brinkmann, C., Bergmann, M., Huang-Lachmann, J., Rödder, S., & Schuck-Zöller, S. (2015): Zur Integration von Wissenschaft und Praxis als Forschungsmodus - Ein Literaturüberblick. Report 23, Climate Service Centre Germany, Hamburg.

Brown, V., Harris, J.A., & Russell, J. (2010): Tackling Wicked Problems: Through The Transdisciplinary Imagination. London and New York: Earthscan.

CASS (Konferenz der schweizerischen wissenschaftlichen Akademien)/ ProClim (Forum fur Klima und Global Change, Schweizerische Akademie der Naturwissenschaften) (1997). Forschung zu Nachhaltig- keit und Globalem Wandel – Wissenschaftspolitische Visionen der Schweizer Forschenden. Bern: ProClim. http://www.proclim.ch/4dcgi/ portal/de/Media?672, Aufruf: 04.12.2015.

Clarke, A. (2012). Situationsanalyse. Grounded Theory nach dem Postmodern Turn. Hrsg. und mit einer Einleitung von Reiner Keller. Wiesbaden: VS-Verlag für Sozialwissenschaften.

Defila, R., Di Giulio, A., & Scheuermann, M. (2006). Forschungsverbundmanagement. Handbuch für die Gestaltung inter- und transdisziplinärer Projekte. vdf Hochschulverlag AG an der ETH Zürich.

Defila, R., Di Giulio, A., & Scheuermann, M. (2015): Managementverantwortliche inter- und transdisziplinärer Verbünde – Rollen, Kompetenzen, Karrieren. Zeitschrift "Forschung. Politik - Strategie – Management“, Heft Nr. 3+4/2015, UniversitätsVerlagBielefeld.

Fernandes, R., Simon, H.A. (1999). A study of how individuals solve complex and ill-structured problems. Policy Sciences 32(3): 225-245.

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher, W., Joye, S., Pohl, C., Wiesmann, U., & Zemp, E. (Eds.) (2008). Handbook of Transdisciplinary Research. Dordrecht: Springer.

Jahn, T., & Schuldt-Baumgart, N. (2015): Wege in eine nachhaltigere Wissenschaftslandschaft – Paraderolle für den Dritten Sektor. Politische Ökologie 140: 43–48.

Jahn, T. (2008). Transdisziplinarität in der Forschungspraxis. In M. Bergmann and E. Schramm (Eds.) Transdisziplinäre Forschung. Integrative Forschungsprozesse Verstehen und Bewerten pp. 21-37. Frankfurt/New York: Campus Verlag.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: between mainstreaming and marginalisation. Ecological Economics 79: 1–10.

Klein, J.T. (2014). Discourses of transdisciplinarity: looking back to the future. Futures (63): 68-74.

König, B., Lundie, S., Kuntosch, A., & Wortmann, L. (2015). Anforderungen an Managementverantwortliche in der Planungsphase von inter- und transdisziplinären Verbundvorhaben – eine Reflexion. Schwerpunktheft "Managementverantwortliche inter- und transdisziplinärer Verbünde" (Special issue "Managers of inter- and transdisciplinary research groups") der Zeitschrift "Forschung. Politik - Strategie - Management"(Gast-Hrsg. R. Defila, A. Di Giulio, M. Scheuermann), Heft Nr. 3+4/2015, UniversitätsVerlagBielefeld.

Kröger, M., Rückert-John, J., & Schäfer, M. (2012). Wissensintegration im nachhaltigen Landmanagement. Inter- und transdisziplinäre Problembeschreibung im Projektverbund ELaN.

Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, P., & Thomas, C.J. (2012). Transdisciplinary research in sustainability science – practice, principles and challenges. Sustainability Science 7 (Supplement 1): 25-43.

Mogalle, M. (2001). Management transdisziplinarer Forschungsprozesse. Birkhauser.

Sarkki, S., Niemelä, J., Tinch, R., van den Hove, S., Watt, A., & Young, J. (2013). Balancing credibility, relevance and legitimacy: a critical assessment of trade-offs in science–policy interfaces. Science and Public Policy (2013) doi: 10.1093/scipol/sct046

Schäfer, M., Ohlhorst, D., Schön, S., & Kruse, S. (2010). Science for the future: challenges and methods for transdisciplinary sustainability research. African Journal of Science, Technology, Innovation and Development (AJSTID) 2(1): 114-137.

Scholz, R.W., Mieg. H.A., & Oswald, J.E. (2000): Transdisciplinarity in groundwater management: towards mutual learning of science and society. Water, Air and Soil Pollution 123: 477-487.

Schön, S., Kruse, S., Meister, M., Nölting, B., & Ohlhorst, D. (2007): Handbuch Konstellationsanalyse. Ein interdisziplinäres Brückenkonzept für die Nachhaltigkeits-, Technik- und Innovationsforschung. Oekom, München.

Scott, J. 2000 [1991] 2nd Edition. Social Network Analysis: A Handbook. Newbury Park: Sage.

Thomas, A., & Wehinger, T. (2009): Situationsanalyse: Die Ausgangssituation kennenlernen, relevante Akteure und Gruppen identifizieren und für die Zusammenarbeit gewinnen, gemeinsam Probleme und Potenziale erkennen. In V. Hoffmann, A. Thomas and A. Gerber (Eds.) Transdisziplinäre Umweltforschung. Methodenhandbuch pp. 72–88. München: oekom Verlag.

Thompson-Klein, J. (2014).Discourses of transdisciplinarity: Looking Back to the Future. Futures, 63 (2014): 68-74.

Zscheischler, J., & Rogga, S. (2015). Transdisciplinarity in land use science – A review of concepts, empirical findings and current practices”. Futures 1: 28-44.

Experiences with knowledge integration methods in an inter- and transdisciplinary project of sustainable land use in North East Germany

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Abstract: This paper draws on experiences of the inter- and transdisciplinary research project ELaN which has been carrying out various methods of knowledge integration throughout a five year research process. ELaN had the aim to develop innovative water and land use options in the North East of Germany. During the initial phase of the project, a joint problem formulation has been developed in several iterative loops with the method of constellation analysis. Further along in the process the results of the 14 sub projects were integrated in several synthesis products: an administrative manual with recommendations regarding the use of treated waste water; a decision support system for farmers that contains a variety of land use options depending on different groundwater levels; and scenarios of land use options depending on different framework conditions and governance recommendations for sustainable water and land use options. Additionally the main results of the project were summarised in 11 core statements. These synthesis products were discussed with the respective target groups to different extents. The paper provides in-depth empirical insights of applying a range of methods and whether they were more appropriate for integrating knowledge from different disciplines or to serve as boundary objects between science and practice. We analyse whether knowledge integration via the different synthesis products results in system, target or transformation knowledge. Furthermore we differentiate between consultative and participative transdisciplinarity, referring to the intensity of exchange with practitioners and processes of mutual learning. Finally, we refer to restrictive and favourable structural factors for successful knowledge integration. The paper concludes that a systematic design and management of knowledge integration processes is crucial but that the nature of the problem at stake, as well as political or societal windows of opportunity, are just as important for successful transdisciplinary research processes.

Keywords: interdisciplinarity, transdisciplinarity, knowledge integration, system knowledge, target knowledge, transformation knowledge

Introduction

This paper draws on experiences of the inter- and transdisciplinary research project ELaN which has been carrying out various methods of knowledge integration throughout a five year research process. The aim of ELaN was to develop innovative water and land use options in the North East of Germany. After an introduction of the projects' focus we describe a conceptual orientation for structuring the analysis of inter- and transdiciplinary research processes and detail the methods which were applied in ELaN. In the second section we elaborate on the experiences with inter- and transdisciplinary knowledge integration referring to the different synthesis products and give insights into favourable and restrictive structural conditions. In the final section results are discussed and conclusions drawn.

Inter- and transdisciplinary research in sustainable land management: the project ELaN

Land use research exemplifies the challenges that have arisen from the sustainability paradigm. Land is central in human-nature interactions. Its functions such as land based production (food and non-food), space for recreation and the provision of ecosystem services are highly threatened by current trends such as climate change, globalisation, demographic changes and energy politics (Pérez-Soba et al.,, 2008; Zscheischler & Rogga, 2015). To be able to deal with such complex and uncertain problems an integrated socio-ecological systems perspective has gained importance in this field. This development reflects a more integrative understanding of land and soil as a limited resource and its diverse societal functions (Zscheischler & Rogga, 2015).

ELaN[1] is an example of a research project with an integrative perspective, combining two thematic areas which - so far - have rarely been dealt with together: water and nutrient management on the one side and land use on the other. One of the main strands of the project is the current German practice of discharging treated waste water into surface water with negative consequences of regional losses of water and nutrients as well as eutrophication of rivers and oceans. In ELaN, scientists from different disciplines have been investigating whether the use of treated waste water has the potential to serve as one element of sustainable water and land use management. A central question was to estimate the risks of applying treated waste water for the quality of the soil and the ground water. Parallel to exploring different options of water management, land use options which are adapted to different ground water levels have been analysed. These analyses were embedded in considering the current legal, institutional and political framework conditions with the objective to formulate recommendations for adapted governance measures. The potential of using treated waste water has been investigated at two sites in the North East of Germany: areas which were formerly used as sewage farms in the outskirts of Berlin and (degenerated) fenlands in rural areas of Brandenburg.

ELaN comprised an interdisciplinary team of 12 institutional partners and approximately 40 scientists from different disciplines e.g. from natural sciences like hydrology, soil science, and toxicology, engineering specialising in waste water management and social sciences such as sociology, political sciences and economics. It was structured in four thematic sub areas (water and nutrient flows, land use, socio-economic governance and knowledge integration) with altogether 14 sub projects and was coordinated by a team of five interdisciplinary scientists who represented the four sub areas. One of the 14 sub projects was responsible for supporting and reflecting inter- and transdisciplinary exchange throughout the whole research process. The authors of this article were responsible for this sub project[2]; the sub project leader was leading the sub area “knowledge integration” and was one of the members of the coordination team.

Characteristics of inter- and transdisciplinary research

Sustainability research usually demands an inter- and transdisciplinary research design which allows for integration of knowledge from different disciplines as well as experience from practice. It usually deals with \`wicked´ problems, that is the existence of different stakes of actors involved as well as disputes (Mobjörk, 2010) over the problem’s relevancy and/or ways

[1] ELaN was funded from 2011 to 2015 by the German Federal Ministry of Education and Research in the research programme “Sustainable Land Management“. More information: www.elan-bb.de

[2] The authors thank Dr. Melanie Kröger for her contribution to part of the analyses which are described in this paper.

to deal with it (Pohl & Hirsch Hadorn, 2008). Because of the diversity of perceptions, interests and visions for the issues at stake, problem analysis and the development of solutions usually require forms of participation and cooperation between scientific disciplines and actors from outside academia (Brandt et al., 2013; Zierhofer & Burger, 2007). By linking scientists and practitioners, and integrating the diverse perspectives, it is expected to gain more socially robust problem solutions (e.g., Lang et al., 2012; Scholz & Binder, 2011; Zierhofer & Burger, 2007; Becker & Jahn, 2006).

In the past decade various attempts were made to structure transdiciplinary research, to propose quality criteria, and to find a consistent set of methods for process management and the generation of satisfying results. According to Jahn et al. (2008), Pohl and Hirsch Hadorn (2008), Lang et al. (2012), and Brandt et al. (2013) an ideal-typical transdisciplinary process can be subdivided into ***three phases***. The first phase consists of a collaborative problem framing, including identification and structuration of the life-world problem and the conceptualisation of a suitable methodological framework. The second phase strives for the co-creation of solution-oriented and transferable knowledge, while in the third phase the produced knowledge becomes integrated and finally applied.

Additionally different ***knowledge types*** are differentiated in literature which point out the underlying motives and rationales for transdisciplinary research (see also CASS/ProClim, 1997; Brand, 2000). According to Pohl and Hirsch Hadorn (2007), transdisciplinary research projects can be characterised by their research focus and respective generation of a) *system knowledge*, b) *target knowledge*, and c) *transformation knowledge*. System knowledge focuses on the causes and effects of life-world problems, social-ecological system interactions and dynamics as well as impact assessments of potential solutions from an analytical perspective (Becker & Jahn, 1999). CASS/ProClim (1997) speak of system knowledge as knowledge that generates insights about the current status quo of complex systems. Target knowledge, in contrast, addresses what kind of research objectives (as targets or desired future states) shall be defined, elaborates their societal foundations and ethical justifications, and identifies relevant socio-political discourses. From an operational perspective transformation knowledge provides solution-oriented, practical guidance and strategies for sound implementation of solutions. Transformation knowledge is thus knowledge about the way from the actual to the desired state. Even though these knowledge types differ in how they approach and structure life-world problems, they are largely interdependent.

According to Mobjörk (2010) the ***degree and scope of collaboration*** can be used as categories for structuring transdisciplinary research. The extent and the degree of collaboration between actors within and outside academia can vary among research phases and between research approaches. On a conceptual level, Mobjörk (2010) distinguishes between participative and consultative research approaches. According to him `consulting´ refers to a limited involvement of societal actors who have the role of responding to problem descriptions and/or suggested solutions but are not actively involved in the knowledge production process. In contrast, participatory transdisciplinary research fully and equally integrates the knowledge of social actors outside academia with scientific knowledge. The distinction between consulting or participative approaches is based on the roles societal actors are assigned in a transdisciplinary approach. This is reflected in the intensity of the actors' involvement which can be placed on a gradient, ranging from being solely informed on the one pole, for example by leaflets, exhibitions, or publications, to full integration into the co-design of a research process. Between these poles one finds a broad range of further functions for participating actors, such as providing data, probing and feedback, planning and deciding, or implementing (e.g., Stauffacher et al., 2008).

As a further conceptual category distinct ***types of outcomes*** can be differentiated. Mitchell et al. (2015) diagnosed outcomes as a blank spot in transdisciplinary research, being mainly concerned with process design and conduct so far. The authors distinguish between: a) the generation of relevant stocks and flows of knowledge, that is knowledge which moves between disciplines and theory and practice; b); outcomes of mutual and transformational learning by research participants to increase the likelihood of persistent change; and c) most far-reaching, a tangible improvement in the situation or field of inquiry (institutional or biophysical) as an outcome. The latter in particular requires a deeply reflexive practice from all actors involved. While the types of outcomes of situation, knowledge, and learning are distinguishable conceptually, in practice they are closely related and permeable (ibid).

These categories will be used to characterise the different participation and knowledge integration processes in ELaN.

Methods of inter- and transdisciplinary research in ELaN

Throughout the project a broad range of practitioners in the field participated in various ways to take the diversity of perceptions, knowledge and needs in different policy and practice areas into account. The most intensive exchange took place with the advisory board which consisted of practitioners from relevant sectors such as water management, agriculture, nature protection, energy production and regional planning. Meetings with the advisory board were scheduled once or twice in the year for the discussion of important mile stones of the project such as the problem formulation and the design of scenarios, as well as drafts of the main end products (synthesis products). Besides these meetings, bilateral consultations with single members took place concerning more specific questions. Beyond the advisory board actors from responsible administration, regional planning, agriculture and associations in the field of water- and land management were included via interviews and target specific stakeholder workshops. Participation via the advisory board and larger workshops were planned and designed by the coordination team in close cooperation with the sub project which was responsible for inter- and transdisciplinary exchange. Smaller workshops targeted at exchange about one of the synthesis products were planned by one or several sub projects of the thematic sub areas, which were, again, supported by the sub project which was responsible for methods of inter- and transdisciplinary knowledge integration. Support was offered regarding the design of the workshop, the moderation and reporting of the results.

Knowledge integration has been carried out in all phases of the ELaN project aiming for different integrative products. In the first phase of the project a participatory mapping and visualisation approach (constellation analysis) was used to generate a common problem understanding within the research team and between the participating scientists and regional practitioners[3]. This process, of a ***joint problem formulation*** was carried out in several iterative loops, giving all participating researchers several opportunities to contribute from their disciplinary perspective (one day workshop with the whole research group, possibility of commenting on drafts individually). The knowledge of different stakeholders was integrated

[3] Constellation Analysis is a method which was developed for inter- and transdisciplinary exchange (Schön et al., 2007). It combines a visualisation of the relations between four types of elements (natural elements, technical elements, actors and systems of signs) with an analytical text. Details of applying constellation analysis in ELaN are described in Schäfer, M. et al., 2014 and Kröger et al., 2012.

via interviews, discussion in a workshop with 38 participants from different sectors and an advisory board meeting. The participants of the advisory board were also invited to comment on a draft of the problem formulation. The process was led by the sub project which was responsible for knowledge integration in ELaN (Kröger et al., 2012, Schäfer et al., 2014).

Throughout the 2nd till the 5th year of the project the results of the disciplinary sub projects were integrated in several end products addressing different target groups (synthesis products). Interdisciplinary integration mostly took place in working groups with researchers from different sub projects. Depending on the envisioned end product these groups were meeting on a regular or a more spontaneous need oriented basis. All ***synthesis products*** were presented and discussed twice at the annual meeting of the whole project consortium. Additionally, the interdisciplinary coordination team, which met approximately every two months, kept track of the scope of the integrative end products, possible intersections and the respective deadlines. Transdisciplinary knowledge integration took place mainly via target specific workshops, consultation with single practitioners and the advisory board meetings.

In the last phase of the project (5th year), the interdisciplinary coordination team started a process of formulating 11 ***core messages***, trying to bring together the main results of the whole consortium. This integrative product was, again, accomplished in iterative loops, led by the coordination team and the sub project which was responsible for knowledge integration. A draft of the core statements was intensely discussed at a meeting of the whole project consortium. After re-formulation all participating scientists had the chance to comment on the 2nd version. The core statements were also discussed in the last advisory board meeting.

Table 1 gives an overview of the integrative products of ELaN, the designated target groups, the envisioned knowledge type, the degree of collaboration, the strived for types of outcome as well as the applied methods of transdisciplinary participation.

The analysis of the inter- and transdisciplinary processes of mutual understanding is based on participatory observation methods and quantitative evaluation questionnaires as well as semi-structured interviews with consortium and advisory board members. All of the four consortium meetings have been observed, followed by a short evaluation via questionnaire after each meeting. Additionally the working group meetings which dealt with the development of scenarios and the Decision Support System (DSS) have been observed. In the last phase of the project all scientists were presented with a questionnaire which dealt with the quality of inter- and transdisciplinary exchange. Additionally, the scientists who were responsible for coordinating the development of the integrative end products were interviewed in the last phase of the project. Regarding transdisciplinarity, all of the five advisory board meetings have been analysed via participative observation and two advisory board members were interviewed. Further on, several target specific workshops, e.g. with farmers, the responsible actors for former sewage irrigated fields etc. were observed. These observations are accomplished by three face-to face test runs of the Decision Support System with farmers and representatives of organic associations and observation of one training course for about 15 farmers.

Table 1. Overview of the synthesis products and conceptual categories for reflection

Synthesis Product	Target group	Envisioned knowledge type	Degree of collaboration	Types of outcome	Mode of Transdis-ciplinary exchange
Problem Formulation	Researchers; Project stakeholders	System knowledge	Consultative; Giving feedback	Flow of knowledge	Interviews; Workshop; Feedback to draft
Integrative end products for different target groups					
Scenarios	Researchers; Regional planners; Land owners; Farmers; Administration (land; water)	System knowledge; Target knowledge	Participative; Providing data; Giving feedback	Flow of knowledge; Mutual learning	Advisory board Workshops (farmers, responsible actors for former sewage irrigated fields)
Governance recommen-dations	Administration (land; water); Regional planners	System knowledge; Target knowledge	Consultative; Giving Feedback	Flow of knowledge	Advisory board; Feedback to draft
Manual	Administration (water) Water and soil associations	System knowledge; Target knowledge	Participative; Co-design; Giving feedback	Flow of knowledge; Mutual learning	Advisory board; Consultation for project design; Feedback to draft
Decision Support System	Land owners; Farmers; Agriculture consultants	Transformation knowledge	Consultative; Giving feedback	Flow of knowledge; Aiming for 'change of situation'	Workshop with farmers; Usability tests
Core Statements	Researchers; Project stakeholders	System knowledge; Target knowledge	Consultative; Giving feedback	Flow of knowledge; Mutual learning	Workshop; Feedback to draft

Analysis of inter- and transdisciplinary knowledge integration in ELaN

Analysis of the quality of the inter- and transdisciplinary process

In the following paragraphs the knowledge integration processes for each of the synthesis products are detailed and analysed.

Joint problem formulation was an important step, especially for a common basic understanding within the project consortium. The evaluation of the one-day consortium meeting, where a draft of the problem formulation was discussed, showed that two thirds of the participating scientists agreed completely to the statement that visualisation with constellation analysis was helpful for their understanding of the overall context of ELaN and that the discussion supported them in getting to know the perspectives of the other sub projects better. The following quotes of participating scientists indicate that processes of mutual learning have to some extent taken place and that the discussions have contributed towards cognitive and social integration of the project team. *"It was helpful to see all the* *aspects which one hasn't always present together in one picture. It was good to look at it as a group and discuss it." "For me as a hydrogeologist who moves in a quite narrow range, it was interesting to see all the other perspectives. Up to now I didn`t approach the project with the overall picture but with my detailed research question."*

Regarding the quality of integrating transdisciplinary knowledge, the advisory board members had an active role in bringing in their perspectives during an advisory board meeting. Some of the members also used the chance to comment on a draft of the problem description. The additional discussion with 38 stakeholders from different areas (e.g. water management, agriculture, nature protection) made different perspectives on the topic clear at an early stage of the project and offered a first chance to exchange ideas in this heterogeneous group. However, the duration of four hours was probably too short for deeper discussions so that integration at this point had a consultative character. Half of the participants filled out an evaluative questionnaire. The majority agreed to the statement that the workshop had motivated them to exchange ideas with colleagues; two thirds agreed to the statement that the exchange between scientists and practitioners functioned well (5 point Likert scale).

The ***manual*** about risk assessment for the use of treated waste water first aimed to generate target and transformational knowledge for actors who are planning to use this water resource for land irrigation. In the course of the project, this objective had to be adapted for two reasons. One is that the monitoring results regarding the degradation of problematic remaining pollutants were diffuse: while some substances were reduced considerably, others remained in the soil or were only partly degraded. This meant that it was not possible to make absolute statements on the risk of using treated waste water (for groundwater pollution) but only very context specific statements taking into account also the soil type, position of the groundwater layer etc. The second reason to adapt the scope of the manual is rooted in political context conditions. Discussions in the European context about "water re-use" increased the necessity to reflect about new water management options on the one side. On the other side the leeway for decisions which go beyond the current legal restrictions was reduced since national and regional government bodies are waiting for general guidelines of how to deal with treated waste water in the future. Due to these context conditions ELaN could not provide transformational knowledge but primarily provided actors with supportive system knowledge for future decision processes. Moreover, the ongoing debates at the European level provided a favourable window of opportunities for discussion and reflection on a national and regional level. Actors were grateful that ELaN gathered distributed and fragmented knowledge e.g. about the risks of disposing of waste water in the traditional way (into surface waters) compared to the innovative option of using it for land irrigation. The discussions about the potential risks of using treated waste water were carried out in close interaction between science and actors from administration. Actors of the administration intensely commented on the draft of the "manual" (now called 'recommendations for risk assessment'). The mutual learning processes are expressed in this quote of a member of the advisory board: *"I think something has really changed from the first session till now – on both sides. At the beginning, there was a complete refusal* [to use treated waste water for land irrigation] *on the one side against the other side saying 'We are just doing it this way[4].' And then, in the course of the project, both sides approached each other."*

[4] The advisory board member is referring to one of the few sewage treatment companies which is using treated waste water for irrigation of agricultural areas with a permission which was given approximately 30 years ago.

The ***scenarios*** served primarily for interdisciplinary knowledge integration. Throughout a period of two and a half years there were regular meetings of a working group with scientists from different sub projects (altogether 10 meetings with 5-10 participants each). In the first phase of the scenario construction process the general design of the scenarios (e.g. quantitative versus qualitative, time scale, main drivers) was discussed and decisions for scenario design and content were deliberated. In the second phase the working group focused on bringing together results from different sub projects such as data on groundwater levels in fenland areas, available land use options for different groundwater levels and context conditions for certain land use options (e.g. necessary equipment, market conditions and subsidies). These combined results were used for developing the Decision Support System as well as the scenarios. The cooperation in this group was evaluated as being very fruitful since all of the participating sub projects benefited from the process of knowledge integration. Through the exchange social scientists deepened their knowledge about natural processes and natural scientists learned more about interrelations and systemic aspects of their own field of expertise. One colleague stated that *"something new is created"* due to the cooperation between natural and social scientists within the project. One can therefore conclude that mutual learning took place within the group of scientists. Regarding transdisciplinary cooperation the scenarios were meant to broaden practitioners' perspective on different future options for water- and land management and therefore aimed at a reflection of target knowledge. Practitioners' knowledge on main drivers, water and land use options as well as influencing market and governance aspects was integrated in the context of an advisory board meeting, a workshop with farmers and a workshop with responsible actors for former sewage irrigated fields. However, at all meetings with practitioners there was a certain reluctance to explore possible future trends. The actors – professionals from administration and associations as well as farmers – mostly held on to their field of expertise and the current situation, commenting that exploration of future trends was dubious and "unscientific". It therefore has to be concluded that the scenarios were a good instrument for integrating results of the different sub projects in coherent pictures of future options for water and land management, but that the initial objective of broadening the scope of stakeholders was only met to a limited extent.

Decision Support System (DSS): Fenland restoration or preservation is an important objective in the context of climate protection and preservation of biodiversity. The DSS aimed at facilitating farmers' decisions regarding land use options which are compatible with higher groundwater levels. It was therefore the only integrative product which explicitly aimed at the generation of transformational knowledge. As mentioned above, the interdisciplinary working group, which met regularly, also generated important results for the DSS. Besides the core content – land use options for fenlands with different groundwater levels – it was possible to complement the information for the farmers with data on market conditions and possible subsidies. However, despite one workshop with farmers in the 2nd project year, practitioners were only integrated in a consultative way in the last project phase when the DSS was already programmed and major changes were not longer possible. The usability tests showed that the structure of the DSS was appropriate and the instrument was rather easy to use. Farmers commented however, that they probably will continue with intensive production on drained fenland soils as long as there are no supportive framework conditions as e.g. financial support for producing in a climate friendly way. It can therefore be doubted whether the instrument

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Other members of the advisory board from water administration were very skeptical regarding this option due to the risks of groundwater pollution.

meets the objective to provide farmers with transformational knowledge and results in the outcome of “changing the situation”.

Core Statements: With the formulation of the core statements the coordination team aimed at reaching an agreement about central results of the project in the whole consortium. Since the synthesis products brought together results of certain sub projects only, it seemed reasonable to present the overall results in a focused way. Besides resuming the main project results within the project consortium, this synthesis product was also meant to give an overview for interested practitioners and the broader public. The interdisciplinary discussion about the core statements took place in three working groups during a one day meeting of the whole consortium. The discussion about the interpretation of certain results, as e.g. the risk assessment for using treated waste water, was very lively. It was felt to be fruitful as the results of the evaluation of the meeting showed. Almost 90 percent of the participants agreed that the exchange in the working groups was intense and evaluated the effort of formulating core statements as being valuable. 80% agreed to the statement that the core statements will be an interesting product that succeeds in summarising the most important results of ELaN. Over 90 percent disagreed to the statement that it is not necessary to formulate joint overall statements (5 point Likert scale) After the meeting the scientists of the consortium had the chance to comment on a revised version on an individual basis. Concerning transdisciplinary reaction to the core statements they were discussed at the last advisory board meeting. The members mainly found that the core statements gave a good overview about the projects' results. It could however be observed that they commented only on those statements which dealt with their specific area of expertise. During the advisory board meeting who could be the target group for the core statements was also discussed. Since they cover a broad thematic spectrum from the use of treated waste water to water and land use options for fenlands and former sewage irrigated fields up to governance recommendations, it is not easy to figure out an explicit target group.

Fostering and limiting structural factors for successful cooperation

Structural and organisational factors for successful inter- and transdisciplinary research processes have been dealt with a lot in literature (e.g. Arye & Nettle, 2015; Pohl & Hirsch-Hadorn 2008, Defila et al., 2006, Tress et al., 2005, 2007). This paper therefore only points out some of the crucial aspects that result from participative observation of the exchange processes and which were mentioned in interviews with the participating scientists. As Stokols et al. (2005, 2008) and Tress et al. (2005) point out there is no knowledge integration without discussions; thus, time and space for communication is crucial. Some of the interviewees stressed the importance of adequate time resources for inter- and transdisciplinary exchange processes and mentioned the five year duration of the project positively. *“In my opinion, a duration of five years is absolutely necessary for a project like ELaN with such a lot of involved institutions, cooperation with practitioners as well as design, implementation and monitoring of experiments in the field. The five year duration has helped to get qualitatively sound and practice oriented results.”* Others remark critically that in the original project proposal not enough time and financial resources for the interdisciplinary integration processes were allocated.

For the successful integration process it was crucial that the project leader always put a lot of emphasis on the importance of inter- and transdisciplinary cooperation. Additionally, the process was supported by the interdisciplinary coordination team which met very regularly and ensured that synergies between different sub projects could be exploited and frictions were avoided. The coordination team served as a role model for the rest of the consortium stressing the importance of continuous exchange. Finally it was of great advantage to have a sub project which was explicitly responsible for motivating inter- and transdisciplinary exchange with specific methods, documenting different disciplinary perspectives and regularly reflecting as well as evaluating the quality of the process. The benefit of this project design was acknowledged by several of the project members as the following quote shows: *"The design of an own sub project for knowledge integration does not only make sense but is indispensable. The effort for assuring qualitatively sound knowledge integration should not be underestimated; the surplus is high. The individual sub projects are not able to deal with it besides working on their specific research questions."*

Discussion and Conclusion

The ELaN project builds on a structured process of inter- and transdisciplinary knowledge integration in all phases of the project. Structural and organisational elements such as: the establishment of an advisory board with practitioners from heterogeneous sectors; an interdisciplinary coordination team; a sub project which was responsible for supporting and analysing inter- and transdisciplinary exchange; as well as the project duration of five years proved to be essential for carrying out these integrative processes.

To foster knowledge integration it was helpful to agree on the synthesis products in a rather early stage of the product. ELaN mainly contributed to system and target knowledge with its synthesis products. The output was partly restricted to 'flow of knowledge', resulting also from participation with a consultative character. Mutual learning processes were mainly observed within the group of scientists and the advisory board. The processes of joint problem formulation, scenario development and formulation of core statements seemed to be very valuable for interdisciplinary exchange and knowledge integration. Exchange with practitioners was most intense regarding risk assessment of the use of treated waste water. The question of an overall assessment of risks considering the future quality of surface waters, as well as the precautionary protection of groundwater quality, questions of the regional water balance and biodiversity, is an issue of high uncertainty and characterised by fragmented knowledge. Perspectives on this topic were quite controversial within the group of scientists as well as within members of the advisory board. Due to the discussions on the European level there was a suitable window of opportunity to discuss new forms of treating and disposing of waste water and weighting the potentials and risks of different paths against each other in a systematic way. The results of ELaN supported a holistic debate of this topic by integrating fragmented knowledge from water and land management. Additionally it can be viewed as one of the main achievements of ELaN to bring actors with different sector-specific knowledge together and enhance mutual understanding for each others' position.

On the other side, ELaN was less successful in supporting an open debate about future water and land management on fenlands. In comparison to the topic of using treated waste water this discussion is not as new and characterised by antagonistic positions between farmers and actors from nature protection. While the former stress the necessity for supporting framework conditions (e.g. subsidies for other forms of cultivation of fenlands), the latter view the farmers as being responsible for forms of land use which are adapted to natural conditions. By highlighting the different positions, especially in the process of problem formulation, ELaN enhanced mutual understanding for each others' position and supported those actors from both areas who were willing to find compromises. However, throughout the duration of the project there was no decisive window of opportunity to take first steps in the direction of regenerating fenlands by adapting land use to higher groundwater levels.

The comparison of the outcomes in the two thematic fields underlines that the nature of the problem and political or societal windows of opportunity play an important role for successful transdisciplinary research processes. Transdisciplinary projects in some cases are able to serve as 'sites of experimentation' for testing innovations, but sometimes they can only prepare the ground for adapting innovations in the future by providing system and target knowledge.

References

Ayre, M., & Nettle, R. (2015). Doing integration in catchment management research: insights into a dynamic learning process. Environmental Science & Policy 47: 18-31.

Becker, E., & Jahn, T (Eds.) (1999). Sustainability and the Social Sciences. A Cross-Disciplinary Approach to Integrating Environmental Considerations into Theoretical Reorientation. London: Zed Books.

Becker, E., & Jahn, T. (Eds.) (2006). Soziale Ökologie. Grundzüge einer Wissenschaft von den gesellschaftlichen Naturverhältnissen, Frankfurt a.M., New York: Campus Verlag.

Brand, K.-W. (Ed.) (2000). Nachhaltige Entwicklung und Transdisziplinarität. Besonderheiten, Probleme und Erfordernisse der Nachhaltigkeitsforschung, Berlin: Analytica.

Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D.J., Newig, J., Reinert, F., Abson, D.J., & von Wehrden, H. (2013). A review of transdisciplinary research in sustainability science. Ecological Economics 92:1-15.

Jahn, T., Grießhammer, R., Hirschl, B., Hosang, M., Keil, F., Schröder, W., & Walk, H. (2008). Klimaschutz erfordert Handeln. Beiträge der Sozial-ökologischen Forschung, Bonn, Berlin.

Jahn, T., Bergmann, M., &. Keil, F. (2012). Transdisciplinarity: between mainstreaming and marginalisation. Ecological Economics 79: 1-10.

Kröger, M., Rückert-John, J., & Schäfer, M. (2012). Wissensintegration im nachhaltigen Landmanagement. Inter- und transdisziplinäre Problembeschreibung im Projektverbund ELaN. ELaN Discussion Paper, Müncheberg. (Download: http://www.elan-bb.de/media/pdf/Publikationen/EDP2_Kroeger_978-3-943679-05-2.pdf)

Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C.J. (2012). Transdisciplinary research in sustainability science: practice, principles, challenges. Sustainability Science 7(S1): 25-43.

Mobjörk, M., (2010). Consulting versus participatory transdisciplinarity: a refined classification of transdisciplinary research. Futures (42): 866-873.

Mitchell, C., Cordell, D., & Fam, D. (2015). Beginning at the end. The outcome spaces framework to guide purposive transdisciplinary research. Futures 65: 86-96.

Pérez-Soba, M., Petit, S., Jones, L., Bertrand, N., Briquel, V., Omodei-Zorini, L., Contini, C., Helming, K., Farrington, J.H., Mossello, M.T., Wascher, D., Kienast, F., & de Groot, R.

(2008). Land Use Functions — A Multifunctionality Approach To Assess The Impact of Land Use Changes on Land Use Sustainability. Sustainability Impact Assessment of Land Use Changes pp. 375-404. Berlin Heidelberg: Springer.

Pohl, C., & Hirsch Hadorn, G. (2007). Principles for Designing Transdisciplinary Research. München: oekom Verlag.

Pohl, C.,& Hirsch Hadorn, G. (2008). Methodological challenges of transdisciplinary research. Natures Sciences Sociétés 16: 111-121. (download: http://www.nss-journal.org/articles/nss/pdf/2008/02/nss8204.pdf)

ProClim – Forum for Climate and Global Change. (1997). Research on Sustainability and Global Change – Visions in Science Policy by Swiss Researchers (download: http://proclimweb.scnat.ch/portal/ressources/1122.pdf)

Schäfer, M., Kröger, M., & Rückert-John, J. (2014). Integration of knowledge in inter- and transdisciplinary research projects: use of constellation analysis in a project of sustainable land use management. Paper for the 11th IFSA Symposium from 1st to 4th of April, Berlin, Germany.Download:
http:/2014/ifsa.boku.ac.at/cms/fileadmin/Proceeding2014/WS_1_7_Schaefer.pdf

Schön, S., Kruse, S., Meister, M., Nölting, B., & Ohlhorst, B. (2007). Handbuch Konstellationsanalyse. Ein interdisziplinäres Brückenkonzept für die Nachhaltigkeits-, Innovations- und Technikforschung. München: oekom Verlag.

Scholz, R.W., & Binder, J. (2011). Environmental Literacy in Science and Society. From Knowledge to Decisions. Cambridge: Cambridge University Press.

Stauffacher, M., Flueeler, T., Krueli, P., & Scholz, R.W. (2008). Analytic and dynamic approach to collaboration. A transdisciplinary case study on sustainable landscape development in a Swiss Prealpine Region. Systemic Practice and Action Research 21: 409-422.

Stokols, D., Harvey, R., Gress, J., Fuqua, J., & Phillips, K. (2005). In vivo studies of transdisciplinary scientific collaboration: lessons learned and implications for active living research. American Journal of Preventive Medicine 28(2 Suppl 2): 202-213.

Stokols, D., Hall, K.L., Taylor, B.K., & Moser, R.P. (2008). The science of team science: overview of the field and introduction to the supplement. American Journal of Preventive Medicine, 35(2 Suppl 2): 77-89.

Tress, B., Tress, G., & Fry, G. (2005). Integrative studies on rural landscapes: policy expectations and research practice. Landscape and Urban Planning 70(1-2): 177-191.

Tress, G., Tress, B., & Fry, G. (2007). Analysis of the barriers to integration in landscape research projects. Land Use Policy 24(2): 374-385.

Zierhofer, W., & Burger, P. (2007). Dissentangling transdisciplinarity: an analysis of knowledge integration in problem-oriented research. Science Studies 20(1): 51-74.

Zscheischler, J., & Rogga, S. (2015). Transdisciplinarity in land use science – a review of concepts, empirical findings and current practices. Futures 65: 28-44.

Workshop Theme 3: Pathways towards sustainable agri-food systems – tensions or synergies?

Workshop 3.1: Sustainability of food chains: contested assessments

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In the last two decades the corporate-based food system has been shaken by a loss of reputation, due to concerns about its sustainability. To respond or to anticipate an increasing demand for information about sustainability of products and processes, food businesses have addressed the sustainability issue seriously, investing in technologies, measurement tools, certification schemes and social reporting. This effort has put some pressure on 'alternative food chains' that have introduced the issue among consumers by highlighting the vulnerability of the existing food system, and given consumers the opportunity to choose alternative products and processes with a high sustainability reputation. An increasing number of scholars have developed sustainability assessment of food chains, and, surprisingly, a growing number of studies show that the superiority of local food chains with regard to sustainability is not to be taken for granted. Methodologies with a high reputation for scientific rigour, such as LCA, tend to confirm these limits. However, there is more than a suspicion that existing sustainability metrics are not appropriate to the characteristics of alternative food chains, and that when using them as instruments to influence consumers or policy makers they alter the balance of power in favour of corporates. This workshop aimed to address these issues in relation to European as well as international contexts, and accepted papers from researchers, NGOs and business actors built around the following questions:

- How is the sustainability performance assessment of food systems evolving?
- How do assessments evolve in relation to the evolution of the meaning of sustainability? What is the impact of sustainability assessment on the governance of food chains?
- What are the methodological differences implied in measuring sustainability of local and global food chains?
- Can 'alternative food networks' propose 'alternative sustainability assessment' metrics?
- Are there avenues for collaboration between food movements and global players in creating a level playing field? What can alternative food networks learn from global players? What can global players learn from alternative players?
- How can policies accompany the efforts of actors in the food chains to improve their sustainability performance?