Multi-stakeholder land-water management
How are sustainable measures constructed in practice?

Anne Mette S. Langvad, AnneMette.Langvad@agrsci.dk, Aarhus University, Department of Agroecology

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Abstract

This article explores how multi-stakeholder land-water management is practiced in a sub-catchment setting. This is done through a real-time process study of a single critical case on how stakeholders construct willow plantation as a sustainable measure, i.e. a measure that produces mutual benefits for the water environment, farming and local economy. By introducing Pickering's construct of 'the mangle' a deepened understanding of complex multi-stakeholder management systems and how they can be managed in the direction of sustainable change is obtained. The conclusion identifies implications of the study for EU Water Frame Directive participatory policy and for existing management research in multi-stakeholder land-water management processes.

Introduction

In a European context, the EU Water Framework Directive (WFD) (ECP 2000) is the legislative background of the objective of reaching 'good water status' in all European waters by 2027. The WFD encourage a participatory approach to land-water management in catchment settings. The reason for engaging multiple stakeholders in constructing measures for good water status is stated to be that the quality and ownership to measures will improve, which will facilitate the enforceability of measures and environmental sustainability (ECC, 2012).
The Commission does not determine exactly who should participate and how participation should be performed. However, it does provide a voluntary guideline in which "best practice" is seen as the participation of all stakeholders in all phases of planning and implementation and as shared decision making and shared responsibility for the outcome (ECC 2003). In addition, the Commission has funded a large number of projects with the objective of experimenting with sustainable measure construction in multi-stakeholder participatory partnerships.

The management research in multi-stakeholder land-water management processes builds on a large number of case studies and constitutes an established field. Dominant approaches are all systemic and they stress 'emergent becoming' as a conspicuous feature of the complex systems to be managed. However, approaches derive their theoretical grounding from different sources such as social learning theory (Kolb,1984; Agyris et al., 1996; Wenger, 2000) soft systems methodology (Checkland, 1981; Checkland et al. 1990), and social-ecological adaptive management theory in the tradition of C.S. Holling (1978, 2001). Accordingly, management trajectories follow the 'critical learning system' (Bawden, 2010; Ison, 2010), the theory of building 'communities of practice' (Snyder et.al, 2010), the phases of Holling's 'adaptive cycle' (Stringer et al. 2006; Jiggins et al., 2007) and/or the levels of his 'panarchy' (Westley 2002; Olsson et.al 2004a, Olsson et al. 2004b). Non-sustainable change continues to be a frequent outcome of multi-stakeholder management processes. Explanations derived from the theories stress stakeholders' inability to obtain inter-subjectivity , lack of self-governance and of organizational support , power imbalances among stakeholders, institutional constraints (Ljung 2012), that the right stakeholders did not participate in the right phases of the process (Stringer et al. 2006), or cross-boundary and cross-level linkages with decision makers failed (Westley 2002, Olsson et al. 2007). Due to the frequency of non-sustainable change

outcomes, there is a call for more case studies, developing a deepened understanding of the dynamics of the complex social-ecological management processes and of how they can be improved (Yorque, 2002; Westley, 2002; Ljung, 2012)

One way of obtaining a deepened understanding is by applying existing multi-stakeholder management theory to projects in practice. Alternatively, researchers may contribute to the theorizing (Weick 1995) within the field by employing grounded theory as an analytical approach (Glaser et al. 1967, Eisenhardt 1989, Charmaz 2000, Mäkela et al. 2007) to multi-stakeholder management processes as they unfold in real time (Davidson 2003, Brundin 2007) .

The purpose of this article is to contribute to multi-stakeholder land-water management theorizing and to WFD participatory policy-development by taking a grounded theory approach to a longitudinal real-time process study of how a group of primary stakeholders construct sustainable measures in a sub-catchment setting.

By posing the open research questions: "*How* do multiple stakeholders construct sustainable measures in practice?" and "*When* do they create opportunities or barriers for sustainable change?," this article seeks a deeper understanding of why the process unfolds the way it does and why sustainable change is not an outcome within the time frame studied.

In what follows, the case is introduced together with the longitudinal real-time process study and the grounded theory approach. Next, multi-stakeholder measure construction is narrated in chronology and an analytic scheme is presented. Subsequently, the data are compared with explanations derived from existing theories. Insufficient explanatory power of these theories leads to the introduction of a construct developed by Andrew Pickering in the field of Science Technology and Society studies (STS), namely the construct of 'the mangle'. The mangle explains the barriers confronted by the stakeholders and why the process does not lead to sustainable change. The article concludes by considering the study's contributions to policy and catchment management theory, followed by limitations and recommendations for future research.

The Case, the Study and the Analytical Approach

The process under study form part of a pilot study within an EU project called AQUARIUS (2009-2012). AQUARIUS developed different types of participatory partnerships between water authorities, land managers and scientists enabling farmers to act as water managers. Within these partnerships measures mitigating the consequences of flooding, drought and water shortage and/or improving water quality were developed.

In one pilot area, the Danish catchment of Mariager Fiord, the main challenge is high eutrophication of the fiord stemming primarily from nitrate leaching from agriculture (Bidstrup et al. 2010). For the purpose of constructing measures to reduce nitrate leaching, the sub-catchment setting of Lundgaard's Creek (LC) was chosen, because measurements here showed nitrate leaching to be especially high. A sub-catchment multi-stakeholder group was formed, consisting of representatives for the primary stakeholders in agriculture and water management at sub-catchment level. Primary stakeholders were defined to be those with both management rights and duties. In a Danish context that means farmers, the local and national farmers' advisory services and the local and national water authorities. In Denmark, the local and national farmers' advisory services are owned by the farmers' collective. Local and national advisors were therefore representing sub-catchment farmers in the area, whereas the sub-catchment farmers participating in the group were contributing personal perspectives to measure construction.

The group existed from Nov. 2009 – Dec. 2011. It had as its objective to construct and implement measures for reduced nitrate leaching that were beneficial in the perspectives of the water environment, the farm business and the wider society. This conception of mutual benefits constituted group definition of sustainability. In emic terms the group's objective was to construct 'win-win solutions'. All stakeholders were intended to participate in all phases of the project and only measures that were voluntarily agreed on and supported by all stakeholders should be implemented (Lundgaard's Creek Group 2010) .The specific case,

that is analyzed in this article is the case of willow plantation. Among the measures worked with by the group, willow plantation is critical (Patton 1990, Neergaard 2007), because it is the only one, that fulfills the EU Commission's criteria for "best practice" throughout the multi-stakeholder management process.

For the purpose of theorizing, this article takes a grounded theory approach to a longitudinal real-time process study of multi-stakeholder measure construction (Glaser et. al 1967, Eisenhardt 1989, Weick 1995, Brundin 2007). A real-time study, in which data collection is instantaneous and events are caught in their sequential order (Brundin 2007), is considered especially apt, when complex multi-stakeholder management practices are to be captured. The author conducted participant-observation at meetings held by the group throughout its life time from Nov. 2009 – Dec. 2011. 9 ordinary meetings, 2 specialist meetings, 2 study trips and a meeting with landowners in the catchment were held. Data from ordinary and specialist meetings were gathered by doing word-to-word transcription of the actually occurring talk. Less inclusive field notes and memos were completed in retrospect from study trips and informal personal conversations with group members. In addition to these conversational data, written documents presented or referred to at the meetings form part of the qualitative data material.
Data were analyzed using grounded theory flexibly (Glaser et al. 1967, Charmaz 2000) and bearing in mind the research questions of *how* multiple stakeholders construct measures and *when* they create opportunities or barriers for sustainable change.
Initially, decision events were identified and coded into whether they created 'opportunities' or 'barriers'. Willow plantation was coded according to the measure's use, and it was noted whether measure construction was approached from the level of the 'catchment', the 'legislation' or the 'farm '. Stakeholders' viewpoints were coded into who presented them and whether they represented the interests of the 'sub-catchment environment' or the 'sub-catchment farmer'. Through this procedure it turned out that disciplinarily derived viewpoints were shared across environmental and farming interests, and that interests were sometimes shared within and across stakeholder levels and organizations - and sometimes not. Therefore, stakeholders' viewpoints were finally categorized under the common concept of 'perspectives' and analytically treated at group level. Maps, tools, and calculations describing the water environment and capturing farmers' practices were coded and later categorized and conceptualized as 'instruments' for representation. Gradually an analytic scheme emerged. It was used for selective coding and for identifying holes in the author's knowledge where further empirical analysis or consultation with written documents or with the stakeholders was needed. In a simultaneous step data were being compared with existing theory and preliminary results discussed with stakeholders.

In the next section the case is narrated in chronology (Brundin 2007, White 1987), followed by a presentation and a first interpretation of the analytic scheme. Whereas the analytic scheme (figure 1) is a precondition for the following theoretical discussion, the narrated chronology serves the purpose of providing the reader with a sense of the process as it was practiced by the stakeholders and with a means of evaluating the author's grounded analysis.

Multi-stakeholder Measure Construction in Narrated Chronology
The conception of willow plantation as a potential sustainable measure happened at the second meeting of the group as the result of three parallel incidents: First, a national advisor provided a hydro-geological interpretation of a number of GIS-maps representing the sub-catchment. The maps indicated that water and nitrate run through sandy soil and slowly towards the creek with almost no drainage to short cut the flow. Therefore, the stakeholders agreed that measures would be most efficient if implemented at field level on arable land. In addition, the local environmental authority had recently joined more projects linking local sustainable energy production with agriculture and the environment. This meant that local political and

administrative attention was directed towards the creation of local energy markets. Finally, the local advisory service had just made a business agreement with a newly established willow producers' association north of the LC catchment, according to which the advisory service had to provide logistics for minimizing the costs connected with bringing willow to local power heating plants. Local advisors saw an immediate opportunity for potential willow producers within the LC catchment to join the association and benefit from its linkages of marketing with purchasing. Knowing that willow reduces nutrient leaching from the root zone in comparison to a normal cropping system, the stakeholders saw energy willow production as an obvious measure to work with. At this point in time no distinction was made between growing energy willow as wood or as a perennial crop. Willow production could be part of forestation strategies or renewal of existing hedgerows as well as part of the agricultural cropping system.

Throughout the third and fourth meeting energy willow changed into being considered a perennial crop. A national advisor brought forth, that treating willow as a crop would allow farmers to get subsidized and obtain tax reductions in connection with willow plantation. Contribution margins for willow for chips were evaluated to equal contribution margins for wheat. Even though one farmer evaluated biogas to be more lucrative to the large majority of animal producers within the catchment, at this moment in time calculations all pointed towards good earning opportunities for producers of energy willow.
Having successfully identified energy willow as a 'win-win' opportunity and proceeding towards implementing the measure in practice, the stakeholders ran into a barrier: Knowledge of underground nitrate retention was not readily available. Hence, no clear connections could be made between a specific field within the catchment and nitrate dissolutions in the watercourse and fiord. Confronted with this barrier of not knowing where to plant the willow, the stakeholders decided to construct a tool estimating underground nitrate retention. The estimation could be based on an already developed simple mapping of underground nitrate retention (Hansen 2010).
However, at the fourth meeting no such tool had been constructed. It was argued that the tool rested on uncertainties that could lead to pointing out the wrong fields. Both the national environmental authorities and the national advisory service evaluated the risk of communicating a potentially non-existent environmental advantage to farmers as too high.
This barrier caused another 'win-win' opportunity to emerge: As far as willow's nitrate reducing capacity could be documented at field level, the local authorities showed willing to grant an environmental allowance increasing the amount of manure that a future willow producer would be allowed to bring out per hectare and hence the number of animal units an animal producer would be allowed to produce. A local advisor doubted how interesting willow plantation would be to the majority of dairy producers within the catchment due to their need of space for fodder production. Still, the stakeholders evaluated the environmental allowance option to be of enough interest to Danish animal producers, who typically seek opportunities for expansion, for a specialist meeting, throwing more light on the issue, to be decided on.

At the following specialist meeting an invited leading researcher in agro-ecology could inform the stakeholders, that nitrate leaching from willow had been tested on sandy soil, the dominant soil type within the LC catchment. In comparison to a normal cropping system test results had shown a reduction capacity for willow of approximately 70%, allowing for increased amounts of manure to be supplied accompanied by reduced amounts of nitrogen leaving the root zone. The 'win-win' opportunity now being very clear immediately faded away, when it turned out, that willow was not yet a variable within the nitrate leaching models produced by researchers and used by the authorities for granting environmental allowances. Not being a variable within authorities' decision tool, allowance could not be granted for willow. In fact, the research modeling team constructing the tool, in which the invited researcher was part, had already applied for funding for willow's integration into their models and tools. However, funding was not yet obtained. Due to

an ongoing troublesome debate about when to grant environmental allowances amongst the national environmental authorities, the local and national agricultural advisory service and the local municipality, that took place outside the group, all stakeholders in the group agreed, that for the time being, the municipality could not challenge the national model for environmental allowance decision making.
However, at the specialist meeting yet another 'win-win' opportunity emerged. It turned out that a recently implemented manure act had made it possible for farmers to substitute willow for catch crops, which Danish farmers are obliged to have on 30% of their arable land. But with willow potentially substituting for catch crops instead of being part of the general environmental allowance scheme, it was only possible for a farmer to change up to 30% of his arable land into willow production. The municipality, the local advisors and farmers evaluated this restriction to influence the type of farmer to be potentially interested in growing energy willow. Pig producers, who often buy all their fodder, and therefore could change their whole cropping system into willow production with no consequence for their primary production, were evaluated not to be interested in changing just a minor part. Due to cattle and dairy farmers need for fodder, the agricultural stakeholders evaluated that they would only be able to substitute 15-20% of the 30% catch crop obligation with energy willow production. In this connection, a dairy farmer's suggestion to use willow as bedding for cows was refuted by a local advisor due to no prior experience. The local municipality evaluated the amount of hectares that cattle farmers had available for catch crop substitution by willow to be reasonable in terms of the possibilities within the manure act. Much later, at the seventh meeting, a combination of disinterest from the participating farmers and local advisors' presumption of difficulties with financing willow plantation in times of economic crisis, led to the stakeholder group eventually closing the environmental allowance line of win-win opportunities with a financial barrier.

At the fifth meeting a dairy farmer wanted to know whether willow could be used as waste water cleaner in connection with the milking parlour or with silage. In case willow could save space in the slurry tank and therefore time and transportation costs connected with spreading of slurry, willow would be of interest from a dairy producer's point of view.
The sixth meeting concluded that within the framework of environmental regulation, farmers could apply for permission to use willow for purifying silage water and *then* an evaluation would be made by the municipality. According to the municipality the two other suggestions were not optional. Although he believed the idea to be excellent, the farmer did not apply for permission, because he was not able to evaluate if it would pay in the perspective of production economy. He was also unsure whether an application would put his environmental allowance into unwanted focus.

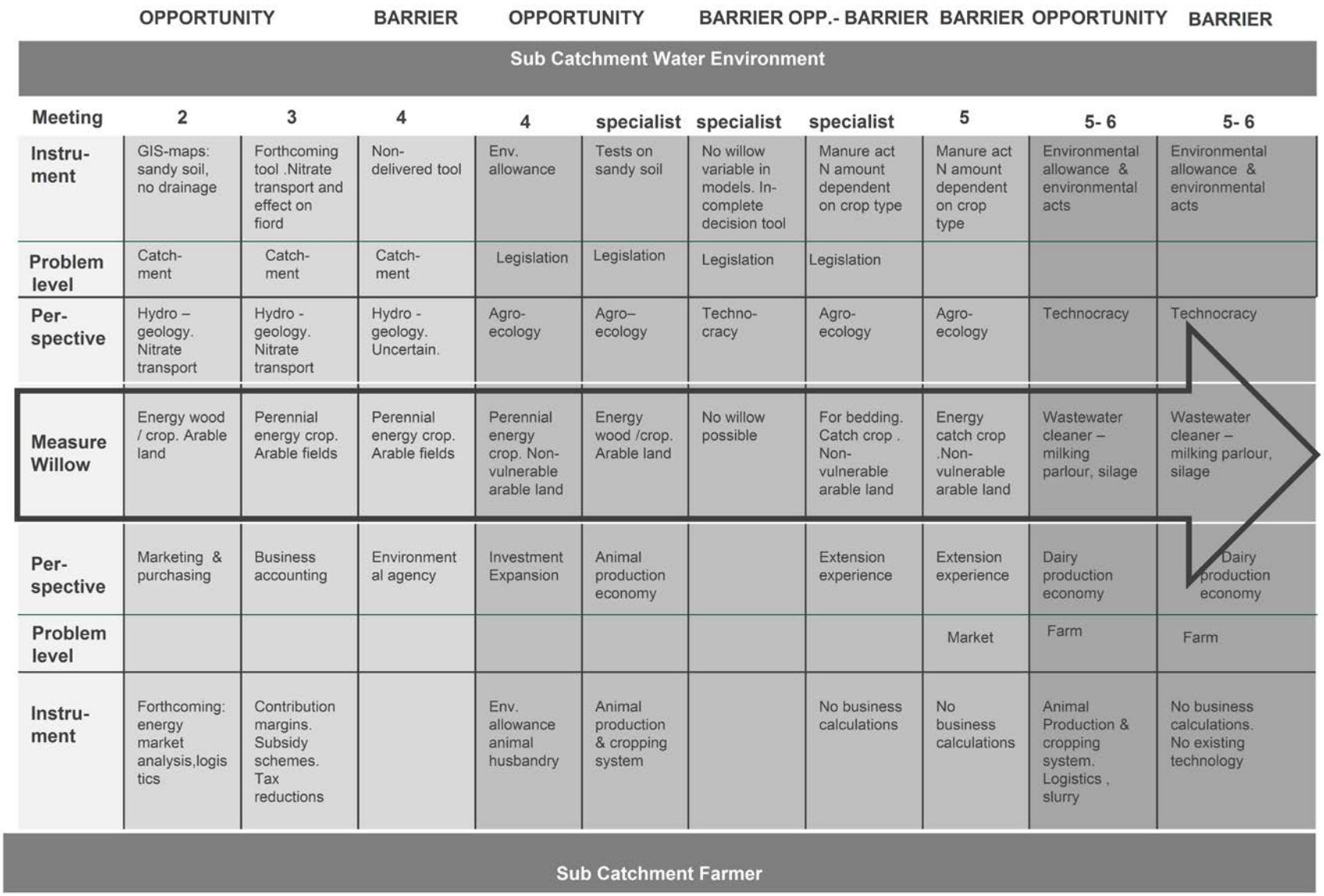

Figure 1: Real-time process analytic scheme showing multi-stakeholder construction of willow as a sustainable measure

Figure 1 is a real-time process analytic scheme showing when and how opportunities and barriers for willow as a sustainable measure were constructed as an output of the stakeholder process. The scheme is based on categories and concepts derived from the data. Figure 1 provides a strong picture of emergence: The sustainable measure is not known in advance and it is changing character in connection with the stakeholders' co-evolving perspectives on the sub-catchment water environment and sub-catchment farmers. New opportunities arise together with shifts in perspectives. It is the barriers that stakeholders confront that trigger the changes in perspectives as well as the scale of problem approach and thus the character of the measure.
With respect to the barriers, first stakeholders abstain from constructing a rough tool for estimating nitrate transportation from subsoil to the watercourse and fiord. Though previously decided on, the national authorities and national advisory service end up with evaluating the risk of uncertainty as too high. Secondly, stakeholders are blocked by the decision tool used by the national authorities for granting environmental allowances not containing willow as a variable. Stakeholders consensually agree that time is not right for the municipality to challenge the environmental allowance system. The third barrier is created due an advisor's lack of previous experience and therefore a lack of business calculations for using willow as bedding. Nobody challenges this evaluation. Fourth, the present crisis within the financing sector is presumed by local advisors to create a barrier for financing willow plantation regardless of farmers' business plans. Even though this presumption is challenged by national advisors, nobody acts. Fifth non-existing business plans, non-existing technology and pre-mature evaluations of possibilities within the legal framework create barriers for willow as a catch crop. Stakeholders rest with premature legal evaluations.

All these barriers centre on knowledge – uncertain knowledge, knowledge not yet integrated, no previous experience, presumptive knowledge and an unacknowledged need for more knowledge to be produced. The next section provides a deepened understanding of how stakeholders can breach the barriers that they confront by changing the way they relate to knowledge.

Analytically breaching the barriers of multi-stakeholder knowledge management
In the tradition of grounded theory (Charmaz, 2000) initially the data are compared with knowledge related explanations and advice derived from multi-stakeholder catchment management theory. Such explanations are institutional (Ison 2010, Jiggins et al., 2007, Olsson et al., 2007), organizational (Snyder et al., 2010), or centered on knowledge's relation with practice and with surprises from the material world (Bawden, 2010; Olsson et al. 2004b; Westley, 2002). An institutional explanation to the knowledge barriers as based on stakeholders' norms and on 'unknowledgeable', incomplete legislative and market structures does resonate with the data. So does an organizational explanation that the stakeholder group is not sufficiently passionately seeking to breach the barriers and that they are not sufficiently encouraged by their organizational environments. However typical advices of ways to build inter-subjectivity (Ljung, 2012) are not going to help in a context where meanings are either widely shared or uncontested. An advice to make structures flexible (Olsson et al., 2007; Ison, 2010; Ljung, 2012) is to turn causation on its head and obtainment of organizational support (Snyder et al., 2010) is a conditioning, not a process managerial advice. Other typical advices are to learn from experience by experimenting in practice or to learn and adapt by seizing windows of opportunity in moments of surprise from the material world (Bawden, 2010; Olsson, 2004a; Westley, 2002). These advices are also not going to help when practical experimentation is exactly that which is blocked and surprises from the material world are not present at all.

Existing theory is not sufficiently sensitive to provide a deepened understanding of dynamics within the stakeholder process and of how they can be improved. I therefore turn in a direction beginning to be

travelled (Asplen, 2008) to the physicist sociologist, Andrew Pickering. Based on a study of how physicists discover scientific facts, Pickering analyzes how knowledge is produced in the plane of practice (1995). Being an STS scholar Pickering puts special emphasis to the symmetry of material and social agency but in a unique, temporally emergent and performative way. In Pickering's analytic material and human agency are symmetrical but not interchangeable, they do not – as ANT scholars claim - substitute for one another (Latour et al. 1986). Material agency is captured by instruments such as the maps, tools, schemes, calculations and tests used by the stakeholders to represent both the sub-catchment water environment and the sub-catchment farmer. Human agency is captured in disciplinary perspectives, for instance the hydro-geological, business economic and technocratic perspectives by which sub-catchment stakeholders frame material agency. Both the instruments representing material agency and the human perspectives are enveloped in practice and it is in and through practice that they should be treated symmetrically. Practice is temporally emergent, meaning that the intertwining of material agency with human agency is never known beforehand, it arises through practice.

In order to clarify how knowledge is produced, Pickering introduces the construct of 'the mangle'. Explained in the context of the data, the mangle is the goal-oriented practice that the sub-catchment stakeholders perform trying to construct measures leading to sustainable change by employing different instruments and perspectives to the sub-catchment water environment and the sub-catchment farmer. For instance, the mangle is the goal oriented practice of constructing willow as an energy crop, by employing GIS maps and hydro-geological theory in reading and interpreting sub-catchment nitrate transportation and by employing a business accounting perspective on contribution margins and subsidy schemes representing the farmers' actions. A fact – e.g. that willow as an energy crop is a sustainable measure - has been produced when there is a fit of material instruments and human perspectives with the phenomenal account of what happens when farmers grow willow on a piece of their land. It is not until willow is interacting with farm production and the sub-catchment environment that its properties for sustainability can be evaluated. Therefore, in the case of LC stakeholder construction of willow as a measure no facts have been produced.
Included in Pickering's construct of 'the mangle' is the re-constructing or re-conceptualizing practice that occurs if the phenomenal account isn't accounted for by actual material practice – if, e.g., the agro-ecological research team's hypothesized leaching of willow on sandy soil had not been accounted for by their actual field tests. Interesting with respect to the LC stakeholder group is that they continue to re-construct and re-conceptualize willow plantation as a measure without producing facts, but whenever they confront a barrier. In this sense, the whole process of multi-stakeholder measure construction can be seen as mangling but mangling with barriers instead of facts triggering the change. In other words, instruments substitute for material agency.

In Pickering's terminology 'social mangling' is material agency and collective social agency intertwining. 'Social mangling' suggests that social relations are formed as a result of collectively reconstructing the instruments representing material agency in order to reach reduced nitrate leaching as the intended goal. Social mangling implies building the social relations necessary to make instruments match materiality. Social mangling suggests that group identity is built not as a pure social and communicative activity but as a result of collectively engaging and accommodating instruments to meet materiality through practice. In the context of the data the instruments constituting barriers to the LC stakeholder group are collectively agreed, but they are not socially mangled.

Due to its goal-orientation, the mangle is more than a descriptive construct. It also contains a normative stance towards knowledge. Mangling is a commitment to engage with the material world and to actively try out hypotheses in practice. Therefore the mangle not only explains the dynamics within the group. It

provides the stakeholders of the LC group with advice on *when* and *how* to act differently in order to produce facts.
First, instead of being blocked by the inability to construct an exact mapping of sub-soil nitrate retention, the stakeholders should have constructed a tool based on the best available scientific estimations. No environmental risk would have been implied in putting such a tool to use and due to stakeholder agreement of voluntarity on win-win premises; farmers would only have planted willow if lucrative for the farm business. On the basis of implementing willow plantation in practice and measuring its effect, a sustainable fact could have been either refuted or produced.
Confronting the second barrier of willow not being a variable within the environmental allowance decision tool, the stakeholders should have used their combined organizational power to influence willows integration into the tool. Because all the primary stakeholders at all organizational levels were present in the group, they had unique cross-boundary and cross-level linkages to decision makers at a national level. Together with the research team that had already once applied for funding, stakeholders could have influenced willow's integration into the environmental allowance scheme for the benefit of the environment and of farming. As a result of social mangling and a commitment to finding facts, the group could have transformed into a macro-actor and strengthened its group identity.
The presumed difficulties with financing could have been mangled by producing business calculations at farm level and by using these instruments to build relations with local representatives for the banking sector at an organizational level.
Having confronted barriers at both catchment level and barriers and at the legal and market macro levels, the group finally turned to approaching the construction of win-win measures from the micro level of a farm. The barriers at farm level were all examples of the lack of proper instruments and of the unacknowledged necessity of finding facts.

Taking a look not only at the barriers that stakeholders confront but at the complex dynamics of the process as a whole, two additional management points can be iterated. First, barriers trigger new opportunities and therefore should be embraced by a management trying to maximize potentials for sustainable change, while simultaneously concretizing these potentials through the use of the mangling principle. Secondly, the sub-catchment water environment and the sub-catchment farmer may support diverse sustainable facts regardless of the level at which they are produced, the specific measure used and the emergent intertwinings of particular instruments with different framing perspectives.
Therefore, win-win solutions can be reached from catchment level, farm level, and the macro structural levels of either the legislation or the market. They can be reached by considering willow as an energy crop, a catch crop, as bedding, or as a wastewater cleaner. They may result from both practical experience and highly specialized science and they may do so in combination with a diverse pool of instruments for representation. What is decisive to sustainable change through the production of facts is how the latter are emergently mangled in the plane of practice.

Conclusion

This single, critical case study has been performed in response to the call for a deepened understanding of complex multi-stakeholder land-water management processes, how they should be organized and managed – and why they frequently do not result in sustainable change.
Grounded Theory has led to a concrete depiction of the elements constituting systemic complexity. The LC multi-stakeholder management system situates between the material environments of the sub-catchment water environment and the sub-catchment farmers. System dynamics of how the group upholds itself by constantly intertwining instruments with disciplinary perspectives in the search for sustainable measures has been outlined. Complex patterns of barriers giving rise to opportunities has been shown to emerge from a

process in which measures, instruments, perspectives and levels of problem approach all emerge in the plane of practice. It is implied that such emergent processes do not necessarily fit with predetermined management trajectories, but that they can be managed emergently by employing the construct of the mangle.

This study has demonstrated that a large number of measures for sustainable change can be developed by a group that is organized according to policy criteria for "best practice" when an additional criteria of creating mutual benefits for the environment, business economy and society is added. However, measures for sustainable change do not implement automatically. Sustainable change does not emerge from goal oriented participation, communication or shared experiences alone. It has been argued that barriers arise from the way that knowledge is managed; more specifically from material agency not being matched by the instruments representing it. This leads to facts not being found. If the mangle's "finding of facts" is used as a normative management principle, a group of primary stakeholders can produce sustainable change at all levels and within all organizations as part of the same process. Then primary stakeholder groups may contribute to the sustainable change of the land-water management system as a whole i.e. to a shift in management paradigms. This is the main contribution of the case study to policy.

Existing catchment management theory stresses emergence, practice, and experimentation and material agency. In this context the novelty of the mangle is to bring material agency into the very process of knowledge construction. Materiality is not just out there to be perceived experientially by active experimentation or to trigger change in moments of surprise. In the form of instruments materiality is inside the process of knowledge construction and decisive to the lack of sustainable outcomes. This insight has deep implications for research within the field and give rise to a need for future theorizing grounded in conceptual analysis.

This case study has been bases on a single critical case. Therefore only future research will tell if its insights can be applied under similar non identical conditions.

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