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Towards Adaptive Urban Water Management: Up-Scaling Local Projects

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Abstract: Increasingly, the need for adaptive urban water management approaches is advertised, but the transition towards such approaches in the urban water sector seems to be slow. The purpose of this paper is to provide an in-depth study of how an innovative approach has been adopted in practice by looking into how contextual knowledge from a local project has been up-scaled to more generic knowledge. Specifically, the paper outlines how two planners from a Danish municipality succeeded in developing a more innovative sewage plan on the basis of a local project with implementation of local handling of rainwater. This insight into the processes of learning aggregation of water practices points towards the important role that the dedicated work performed by local facilitators and intermediaries play in relation to a transition towards more adaptive urban water management.

Keywords: Up-scaling, micro-transitions, adaptive water management, learning, strategic protection, sustainable urban water management

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1 INTRODUCTION

Adaptive water management indicates a new trajectory for water governance under climate change and has become a growing issue in the urban water sector due to a broader political recognition of the need to cope with increasing risks of extreme climatic events in a more sustainable manner (Godden et al. 2011; Pahl-Wostl 2007b; Schluter et al. 2010; Wong and Eadie 2000). The adaptive approach copes more deliberately with future climatic variability in water system (Lim et al. 2005). It represents a response to the criticism that rational engineering, which is traditionally applied in water management, is no longer sufficient to address current and future uncertainties and complexities of the changing climatic and socio-economic conditions (Pahl-Wostl et al. 2008; Wong and Brown 2009). The adaptive approach takes these uncertainties, generated by the influence of nature and society, into account in the development and management of urban water systems (Farrelly and Brown 2011; Pahl-Wostl 2007a; Pahl-Wostl et al. 2008).

In research, it is recognized that a shift from traditional to adaptive water management involves a transition from one regime to another (Lee 1999; Pahl-Wostl et al. 2007; Pearson et al. 2010). The notion of regimes refers to the patterned development along certain technological trajectories and shared cognitive routines within a certain community, which occur in many socio-technical developments in society (Geels and Schot 2007). This includes that a community of practice has been built up in relation to a specific technology or development and the community is self-reinforcing by being reluctant to adopt alternative practices, due to dynamics of entrapment within the status quo (Brown et al. 2011).

The adaptive management has fundamentally different characteristics in comparison with the traditional management. The traditional water management represents a predict and control approach, which relies on a rather centralized and hierarchical governance structure (Brown et al. 2011; Pahl-Wostl 2002; Pearson

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et al. 2010; Stahre 2006), whereas adaptive water management is characterized by a decentralized and more polycentric and horizontal structure at multiple scales (Mcginnis 1999; Olsson et al. 2006; Pahl-Wostl et al. 2010; Pearson et al. 2010). This implies that new forms of communities of practice have to be developed in order for more adaptive urban water management to overtake the traditional approaches.

Adaptive management approaches can be identified in the urban water sector, but the transition towards these seems to be slow (Pahl-Wostl 2007b; Pahl-Wostl et al. 2008). Several studies have identified barriers for transitions towards adaptive water management in the form of e.g. "lock-in" effects and capacity deficits in institutional structures (Brown and Farrelly 2009; Brugge and Rotmans 2007; Morison et al. 2010; Pahl-Wostl et al. 2007; Raven et al. 2011; Schluter et al. 2010). However, less emphasis in research has been on exploring factors that support up-scaling of successful technologies into mainstream regimes, although these provide a better understanding of the dynamics that facilitate a transition (Brown et al. 2011; Farrelly and Brown 2011). By focusing on success factors the ability to facilitate social and institutional change processes is highlighted and enhanced.

This paper contributes to the growing body of research on transitions towards adaptive water management with specific insights on management of such a transition process. Whereas many studies analyze system-wide transitions, this paper adopts the idea of Brown et al. (2011) to study a successful micro-transition, where an innovative project has been adopted in practice. Although this leaves out important dynamics of a transition process, it adds more detailed insights into specific phases of transitions. More specifically, the aim of this paper is to study the dynamics of up-scaling from local projects to plan-making at the local scale. This perspective provides a framework for understanding how contextual knowledge developed in local projects become aggregated into more widely distributed generic knowledge. Such processes of learning aggregation represent a crucial phase in transitions, since innovations have to mature in order to challenge existing regimes (Kemp et al. 1998).

The issue of learning aggregation is explored through a case study of how a local authority succeeded in upscaling tacit and site specific knowledge from a local experiment with sustainable urban drainage systems to more generic formulations about implementation of decentralized technological solutions in a new sewage plan. The case study is analyzed as a successful micro-transition, as suggested by Brown et al. (2011), since emphasis is put on performed aggregation activities within a specific organization - and not for the entire transition as such. By narrowly focusing on a specific transition phase, a successful aggregation and transformation of knowledge at the micro-scale of an on-going transition towards more adaptive management is highlighted. The purpose of the paper is not to evaluate the micro-transition in terms of degrees of sustainability and adaptive water management, but rather, to further our understanding of dynamics leading to up-scaling at the micro-scale as an important step in a wider transition. In taking this perspective, the study argues for the need to strategically address learning aggregation in initiatives to promote adaptive water management.

2 A MICRO-SCALE APPROACH TO LEARNING AGGREGATIONS

Learning aggregation represents an important dynamic of change in relation to regime shifts, according to several studies in transition theory (Geels and Deuten 2006; Geels and Raven 2006; Kemp et al. 1998). Learning aggregation represents the maturing process of an emerging regime, where more regime-like characteristics are developed in the form of mobile and abstract knowledge. This process of maturing is important, since it provides a basis for an emerging regime to gain enough momentum to outmatch existing regimes (Kemp et al. 1998). In the following, we outline the theoretical concept of learning aggregation and describe how it is applied in our micro-scale case study.

The theoretical concept of learning aggregation is especially relevant in the understanding of niche developments in transitions. According to the Multi-Level Perspective (MLP), the niche level represents an important protective space for dispersed innovations in local projects (Geels and Schot 2007). This protective space represents a local phase in a learning aggregation process, where projects to develop and implement new technologies tend to emerge into one or more local practices relatively independently and mainly to create knowledge for their own purposes (Geels and Deuten 2006). Over time, the activities carried out in relation to facilitating such local projects may potentially be built up to gain enough momentum to outmatch an existing regime (Geels and Schot 2007). In many transitions the niche represents an essential phase, where new technologies can emerge and mature, since these technologies cannot immediately compete with existing technological regimes characterized by lock-in and path dependence (Geels and Raven 2006).

This process represents a complex and dynamic process, involving different factors, both internal and external to the niche. Examples of external factors could be pressures from existing regimes or windows of opportunity that take form outside of the niche activities (Van Der Brugge and De Graaf 2010). Internal niche factors relate to understandings of how niche activities are developing and taking new forms, as coordination and sharing technological knowledge become more pronounced within a specific local project and across projects (Geels and Deuten 2006; Geels and

Raven 2006). Such internal niche factors represent important dynamics in relation to understand what enables (or disables) maturing of a niche, and hence, provide an important basis for a transition.

The aggregation and transformation of contextual knowledge into mobile and generic knowledge represents an important niche dynamic (Geels and Deuten 2006; Geels and Raven 2006). Such a learning aggregation establishes shared rules for a broader community, which may lead towards an emerging technological trajectory, see Figure 1 (Geels and Deuten 2006). The notion of shared rules mainly indicates that the knowledge is sufficiently abstracted and packaged so that it is no longer tied to specific contexts, but can travel between local practices (Geels and Deuten 2006). The notion of local and global levels of knowledge reflects that the development of technology follows certain maturity curves, which involve up-scaling in terms of the scales in the Multi-Level Perspective (Rip and Schot 2002).

In order for learning aggregation to occur, dedicated activities and network structures are needed, where knowledge produced in concrete local projects carried by specific actors are developed into global levels of shared knowledge (Geels and Raven 2006). This points towards the important role of intermediary actors, that strategically address the linkage between local practices and global niche expectations (Geels and Deuten 2006; Geels and Raven 2006). This linkage is necessary, since the local and the global phases differ fundamentally. In the local phase, facilitation in a special form of "bricolage" is undertaken in the specific project, which implies a pragmatic process of problem-solving within a local network (Hård 1994). During this process, the project is mainly developed in response to site-specific, contingent and messy practical and contextual elements that characterize local projects (Geels and Deuten 2006; Hård 1994). However, in order for a global phase to take form, there is a need to develop more abstract and generic forms of knowledge. The linkage between the local and contextual forms of knowledge produced in the local project and the production of explicit and generic knowledge by intermediary actors represents an important object of study in order to understand how transitions can be successful in terms of learning aggregation.

This perspective on learning aggregation is studied through a case study on implementation of adaptive urban water management. More specifically, we have chosen to look at the implementation of innovative technologies for local handling of rainwater in the Danish Municipality of Egedal, which lies in the outskirts of Copenhagen. This case study is especially interesting, because it represents a specific attempt to integrate more adaptive water management in practice. The case study allows us to study the learning aggregation in relation to a specific experiment in order to understand how individual actors (as facilitators and intermediaries) can take leadership of transitions towards adaptive water management. The chosen case study is especially interesting, because the involved actors have strategically addressed the challenge of integrating and scaling up of their innovations within their own organisation. The case study represents a good example of a successful micro-transition in terms of learning aggregation, since tacit and contextual knowledge produced in a local project of technology innovation has been aggregated and transformed into more explicit and globally shared knowledge in the form of a new sewage plan. Even though this process merely represents a modest step towards adaptive water management in practice, by focusing mainly on implementation of a decentralized technology in a local project, it provides important insights into the dedicated work involved in transforming local knowledge into global knowledge.

The methodology is an in-depth case study of two

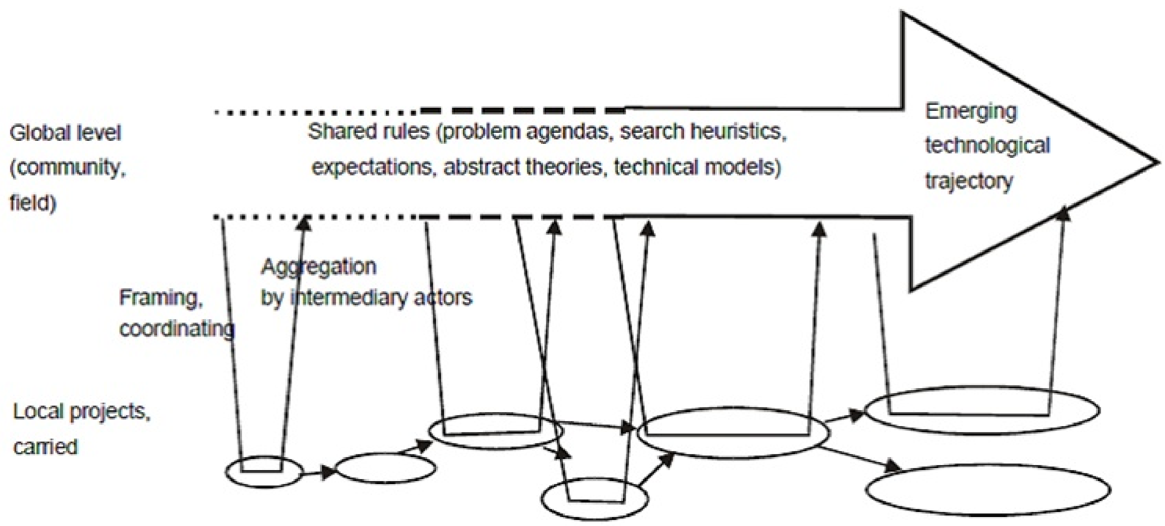

Figure 1. Illustration of technological trajectory carried by local projects (Geels and Raven 2006)

interdependent projects in the aforementioned local authority, namely a large urban development project, which was followed by development of a new sewage plan. Multiple background materials have been collected in the study, including literature review of relevant planning documents and a series of qualitative interviews conducted with policy makers, house owners and other actors involved in the projects. Also, qualitative semi-structured interviews were carried out with the two coordinators of the processes as well as with engineers from the utility company handling the operation of the drainage system. These data provide deep insights on the dynamics and strategies in the complex up-scaling process.

3 FROM A LOCAL PROJECT TO A NEW SEWAGE PLAN

The local authority of Egedal has developed a general practice for implementing decentralized drainage solutions. This represents an example of a successful micro-scale transition in relation to adaptive water management. In the following, we shortly account for this development process.

The process began with a local project, where rainwater collection and usage in private new built houses were developed in combination with local infiltration and open basins for rainwater handling. This project was carried out as an integrated element of the development of a large urban development area mentioned in the Municipal Plan for 2002-2012 (Stenløse Municipality 2001). The construction of 750 new dwellings in the new urban development area provided a window of opportunity for the planners to promote decentralized drainage solutions. The local project of implementing solutions for local handling of rainwater was mainly coordinated by a planner from the urban planning department, referred to as the consultant. This consultant succeeded in convincing others within the local authority to boost the promotion of sustainability concepts in the urban development area (Quitzau et al. 2012).

The consultant wished to promote local handling of rainwater in the new urban area, but the water engineers were reluctant, as they believed this would induce a number of new elements and uncertainties in the system that could not easily be controlled. Instead, the water engineers recommended implementation of a traditional collective system. As a response to this reluctance, the consultant succeeded in getting support for the ideas about local handling of rainwater by forming an alliance with the Head of the Planning Department and the General Director of the local authority. Through this alliance, the urban development project became framed as an innovative project aiming at implementing visions of a water sensitive city in the Municipal Plan, including the implementation of solutions for local handling of rainwater.

The specific technological solutions for local handling of rainwater were mainly developed by the consultant, the Head of the Planning Department, the General Director and a newly hired project leader from outside the local authority. This represents a reorganization of the planning process: Traditionally, the water engineers would play an important role in terms of developing and endorsing piped systems. However, in this specific local project, a decentralized rainwater system was developed, where local handling of rainwater would be implemented by each household instead of the typical design of a collective drainage system. The implementation of local handling of rainwater was delimited to the new urban development area, and in that sense not up-scaled on the basis of the local project alone.

The process was later continued by the ambition of up-scaling the experiences and visions from the local project into a new sewage plan that provides universal guidelines for more adaptive urban water management practices in the local authority (Egedal Municipality 2011). A key person in this process was the coordinator, who was responsible for developing the new sewage plan through involvement of planners from different departments as well as from the utility company.

The process of developing a new sewage plan was initiated due to a national planning reform in 2007 merging the three local authorities of Stenløese, Oelstykke and Ledoeje-Smoerum into the new municipality of Egedal. This necessitated the development of a common Municipality Plan to incorporate the strategies and demands of the three former local authorities. The planners and politicians in the local authority saw this as a window of opportunity to integrate infiltration and reuse of rainwater as basic approaches for rainwater handling. On the basis of the Municipality Plan a new sewage plan also had to be developed.

During the development of the new sewage plan the coordinator was attentive to lessons and experiences from the local project, but wished to include the decentralized solutions through collaboration between the different municipal departments. In order to do that the coordinator assembled a team staffed of primarily non-technical professionals with creative capabilities, cross-disciplinary thinking and relevant knowledge of the field. At the same time, the coordinator was dedicated to engage a broad number of stakeholders, such as the planning department, environmental department, the utility company, and the involved consultant company to work on the practical details. By doing this, the new sewage plan was successfully lifted to a higher level, concerning broader issues such as nature and climate change. At the same time a community was developed that could process and produce new knowledge across existing boundaries.

During the development of the new sewage plan, the coordinator actively sought to build common cognition and language to align different interests among the involved departments.

In the end, the new sewage plan incorporated a number of concrete measures to promote local handling of rainwater in the local authority (Egedal Municipality 2011). The plan clearly builds on the tacit knowledge from the local project, but it also presents new planning instruments providing more formal considerations about how these solutions fit in different settings.

4 AGGREGATING LEARNING FROM A LOCAL PROJECT TO AN OVERALL PLAN

The up-scaling process allows us to study how the contextual knowledge produced in the local project was developed into abstract and generic knowledge in the sewage plan. In the following, we show how this learning aggregation involved different forms of dedicated work to firstly produce the necessary tacit knowledge concerning local handling of rainwater and then to pass on and negotiate this knowledge in order to make it more broadly applicable in the municipality as a whole. The process is illustrated in Figure 2 and provides insights into the different strategies used by the consultant and the coordinator, respectively, to enable the necessary protections and alignments in the process. In the following sections we analyse the different but interrelated processes of learning aggregation taking place.

4.1 Project 1: A Local Project with Local Handling of Rain Water

The implementation of local handling of rainwater in the urban development area represents a local project, where emphasis is put on technology demonstration in a practical context. This is also reflected in the way that the consultant and the other involved actors scoped the project, since emphasis was put on implementing an operational decentralized solution, rather than changing the urban water management practices within the local authority.

The different way of organising the rainwater handling in this local project challenged the existing water management regimes. This is illustrated in the aforementioned scepticism of the water engineers of the municipality, since they would much rather operate a collective system that could be more easily controlled. This reflects the design principles of the traditional "predict and control regime" as Pahl-Wostl (2007b) has pointed out. It also illustrates the situation of lock-in and entrapment that the local project operated within, where current water management regimes work against innovations due to external issues to the niche, e.g. national water regulation and shared cognitive routines among water engineers. This reflects how the dominating community had fixed beliefs about how to frame and identify solutions for urban water management (Brown et al. 2011; Burch et al. 2010).

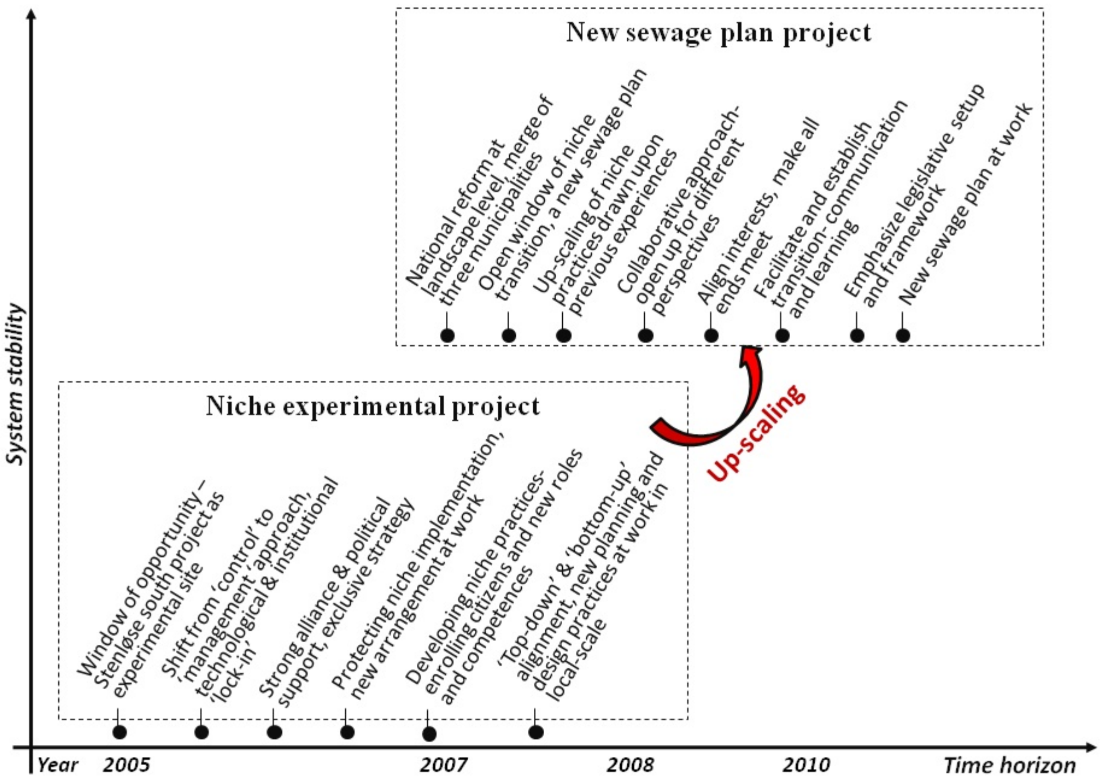

Figure 2. Illustration of the up-scaling process

Due to these dynamics of lock-in and entrapment, the early phase of the local project was characterized by protection strategies in order to overcome the resistance within the local authority to the innovations of the project. The establishment of the aforementioned alliance became the consultant's strategy in order to create support and protection to withstand the resistance due to system inertia. This alliance ensured protection against the pressures from other departments, since it included superior employees with the authority to enact exclusive powers against anticipatory pressures. One of the reasons for the success is the shared objective and understanding within the alliance on how to introduce and protect the innovation in the beginning of the project. It helped to break down the institutional barriers and ensure commitment to the innovative idea at the political level, which was achieved by rationally pointing towards the advantages of such ideas in practice:

> *"If you want to change the organization, it is not enough to have a good idea. The luck was to work together with the General Director of Stenløse. The combination of knowledge on a daily basis of new technology and development of the subject combined with the position of my boss made the possibilities. He could feed the politicians - convince them to do something - and to take risks. He had a very fine relation with the politicians and I could feed him about the facts and practical solutions."* [Consultant, personal communication]

The strategy chosen resulted in an exclusion of the water engineers from the project. This was possible, since the planning department was the main driving force in the project and they were able to handle the decentralized solutions by themselves. The confrontation with the water engineers was hereby avoided by dismissing the formal competences of the technical department for a time in relation to the local project. This exclusion provided a necessary protective space for learning more about implementation of decentralized solutions. This struggle to overcome internal reluctance to the project reflects how an important part of the project was based on the interactions of contextual knowledge and practical skills, as characterized by Hård (1994).

In this local project, the strategy of excluding the water engineers contributed significantly to the successful implementation of the decentralized solutions, although these steps might not seem rational or meet technical expectations. The decentralized solutions, however, were not distributed beyond the urban development area, and in that sense not up-scaled on the basis of the local project alone. As a result, the tacit and contextual knowledge gained in relation to the project was not immediately up-scaled or distributed as a result of the process.

4.2 Project 2: A New Sewage Plan: Up-Scaling by Producing More Generic Knowledge

Although the local project mainly produced tacit and contextually bound knowledge, it also formally paved the way for promoting the decentralized solutions more broadly. The concrete example made it more difficult to maintain the resistance within the local authority and it created a positive setting to facilitate more general discussions about how these solutions could be more widely implemented in the municipality. In this way the local project became a strong driver for promoting decentralized solutions in the new sewage plan, hereby supporting important shifts in the mainstream water management regimes. This illustrates an important process of learning aggregation, where the tacit and contextual knowledge from the local project was transformed into more explicit and generic knowledge in relation to the new sewage plan through the efforts of the coordinator.

A key challenge in the development of the new sewage plan was to ensure that the decentralized solutions met institutional and technical expectations. This represented a challenge, since the integration of decentralized solutions in the existing water management scheme of the local authority induced a number of professional disagreements. Important differences in work styles and environment of the different departments made it challenging for them to collaborate on a common target. Although political support was given at the outset of the planning, the coordinator faced struggles to involve and commit all stakeholders in the local authority. There were many ends to meet and many solutions to be developed:

> *"The planners are clinging to the Municipality Plan. It says we have to infiltrate all storm water. And we say: we may have a problem, as the water may be polluted. The ground water people do not want this water in the ground water, and the people with the streams do not want extra water in the streams."* [Coordinator, personal communication]

The strategy of the coordinator was to form a large alliance to achieve a shared interest of the problem and maintain the project momentum among the involved actors. The coordinator succeeded in establishing a community around the new plan in which common cognition and language were developed by taking a number of actions to stabilize the realization of the innovative plan. Firstly, the coordinator arranged a number of meetings and presented a series of successful cases from other local authorities within the group to explain the problem and compare the difference between

Table 1. Characterization of the two different phases along the micro-transition

	Local project (Phase 1)	New sewage plan (Phase 2)
Context	Context specific, link to local circumstances of the project	Water management regimes within local authority
Community	Small alliance with superior employee	Large alliance with broader stakeholders and professionals
Knowledge	Tacit & contextual	Generic & mobile
Process	"Bricolage" activity	Codification activity
Language	Local & specific	Common & standards
Strategy	Exclusive	Open & inclusive

local practices and the formulation of generic solutions. Equally important, the coordinator deliberately studied and addressed the legislation issue along with the discussion process to ensure that the new sewage plan would be valid within the existing legislative framework. Finally, the coordinator made great efforts to study the technical knowledge needed for the new approach in order to understand different positions of knowledge and competences in the discussion. These strategies reflect attempts to translate tacit and contextual knowledge from the local project to a common language for decentralized drainage solutions through professional discussions.

Thanks to the dedicated work performed by the coordinator and the protective space provided by the municipal council, the coordinator was able to facilitate both cognitive and normative changes in existing sewage plans, thus providing an important shift towards more adaptive urban water management within the local authority. In comparison with the local project, the knowledge developed in the sewage plan is no longer tied to a specific context, which reflects knowledge at a more global level. In the next section we point to important issues in this process.

5 CONSIDERATION OF LEARNING AGGREGATION IN TRANSITIONS

The processes outlined in the case study do not represent a narrative of a complete transition, since it merely describes successful initiatives performed in a specific phase of an on-going transition towards adaptive water management. The case study, however, illustrates important dynamics supporting learning aggregation in developing an experiment into a broader practice in the form of a new sewage plan.

The accumulation and transformation of tacit and local knowledge into more explicit and generic knowledge is reflected in the changes in context-dependency of the involved knowledge (Geels and Deuten 2006). In the local project, the knowledge involved was closely linked to local circumstances, since the approach to implement the chosen solutions was tailored to the specific context of the new urban development area, see Table 1. Furthermore, the knowledge developed was to a large degree tacit as it was connected to the concrete building projects and there were no formal evaluations or professional community to process it. In the sewage plan, the knowledge involved was more abstract and mobile, since the experiences from the local project were discussed among the professionals and the object was described in more general terms. For example, the new sewage plan considers both new built and existing urban areas and points out more universal considerations for implementation of decentralized drainage solutions (Egedal Municipality 2011). The aggregation of knowledge is also reflected in the widened sharing of knowledge, where a broader number of stakeholders became involved in the sewage plan project. The community expanded over time from the original alliance to also include the politicians, the coordinator and finally a number of experts from the technical department and the utility company. Such an expansion of the community represents a sign of aggregation, since it reflects that knowledge has become more widely shared (Geels and Deuten 2006).

An important dynamic of knowledge aggregation is codification (Geels and Deuten 2006). This means that the knowledge is transformed into a more systematic form in order to produce standards, models or written plans that convey underlying principles. In this perspective, the production of a new sewage plan represented a coding process, where the tacit and contextual knowledge was translated to a common language to provide principles for the implementation of decentralized drainage solutions. In a sense, the knowledge gained from the local project was instructive experiences about identifying configurations that work in practice (Geels and Deuten 2006). Although these experiences might seem unimportant, we would argue that they provided rare experiences of planning from an "operational level", since emphasis in planning is often put on visions rather than projects, according to Albrechts (2006). However such knowledge needed to be de-contextualised and adapted by a lager professional community which the second project supported and realized. This suggests that the success of learning aggregation is very much based on the interrelation between the two processes and the combination of production knowledge with the translation of the contextual knowledge into abstract knowledge.

The case study shows that in order for the aggregation of knowledge to occur dedicated work is needed. This is highlighted in the case study, by showing the significant role of strong leadership and agency in the two different phases of the up-scaling process. Both projects showed how single persons become key drivers in such process of change, and how their ability to grasp an idea and persistently pursue this represents an important element to facilitate the desired development (Kemp et al. 1998; Nielsen et al. 2009; Pahl-Wostl et al. 2010). According to Geels and Raven (2006), such dedicated activities and personal efforts are important to establish the link between local practices and global niche expectations. Our analysis indicates that the dedicated work performed by the consultant and the coordinator does not only reflect differences in personal competences and management style, but also shifts in contexts in terms of timing, available resources and framework restraints. This shows how facilitation of aggregation of knowledge involves responses to different contexts and possibilities, as transitions do not represent linear and predictable processes (Conklin 2006; Geldof and Stahre 2004; Shove 1998; Van Der Brugge and De Graaf 2010).

The two projects are very different in terms of strategies and competences to induce the necessary alignments at the local and global niche level, respectively (see Table 1). The consultant was mainly involved in what Hård (1994) terms as "bricolage activities" in response to the local problems and to align heterogenous bits and pieces on location. The knowledge developed at this stage mainly served its own purpose, since emphasis was put on making configurations that worked in practice. The coordinator was mainly involved in codifying activities, which included community building and translation into standards. This represents the production of more generic forms of knowledge with the purpose of providing shared knowledge about decentralized drainage solutions. Moreover, the alignments in the local project facilitated important shifts in the mindsets of politicians and experts within the field, whereas the codification work involved alignment activities mainly in terms of socio-cognitive processes. Again, this illustrates how the success of the micro-scale transition is dependent on the interrelation of the two projects.

A final issue, we wish to raise, is the exclusion and inclusion of the water engineers. In the local project, the consultant excluded the water engineers as a protection strategy. This exclusion was possible because the chosen solutions represent low-tech solutions compared to the conventional pipe systems (Stahre 2006). Such exclusion is problematic, seen from a technical perspective, since it impedes optimization of the entire drainage system, according to the water engineers. However, seen from a transition perspective, the exclusion seemed necessary in the local project, as it made it possible to protect the transition from resistance that could otherwise have stopped it. As the case study shows, the water engineers were later included in the new community of practise around the water plan in order to ensure shared knowledge. The question is whether a more inclusive form of collaboration could have been performed in the local project that would have ensured the involvement of the water engineers earlier in the project. The engineers represent strong technical expertise with technical overview of the entire water system. However, one could argue that what happens in the dominant regime is that water engineers are excluding other experts due to their technology deterministic approach, and that this needs to be challenged in order to further new solutions (Stahre 2006). In a sense, engineers need to see that other solutions can work and the planners need to fail without the inclusion of sewage engineers. In such a way, more opened and shared cognition can be achieved in order for a structured learning aggregation. In this way the development of a new community across the existing different professional fields seems to an important step.

The described micro-transition has been successful, especially, due to the deliberate work carried out to facilitate shared and standardized knowledge on the basis of tacit and contextual knowledge in a practical context. The success of the micro-transition has to a great extent been dependent upon the ability of the two involved intermediaries to enact alignments in actors and systems within their own practical context. Further development of a transition towards adaptive water management will depend on a wider spreading of these initiatives and competences, both in the municipality and at a larger scale.

6 CONCLUSION

The micro-transition described for the municipality of Egedal in Denmark shows that deliberate work to develop, aggregate, and transform knowledge represent an important dynamic in transition processes. Although the result of this micro-transition may not be extraordinary in terms of implemented technologies and substantial changes, the two interrelated processes to a great extent facilitated the cognitive and normative changes in the water management regimes and resulted in a greater institutional and political commitment to sustainable concepts within the local authority. Meanwhile, the learning aggregation obtained through the transition process provides important clues in terms of how the momentum of adaptive water management can be strengthened in practice.

A first clue is that practitioners involved in the planning and implementation of water management may play important roles as facilitators and intermediaries of transitions, since they are well positioned to produce local knowledge and transform this into more generic knowledge.

A second clue is that aggregation and transformation of contextual knowledge into more generic knowledge requires different forms of dedicated work, since the knowledge produced in local projects might provide a necessary window of opportunity to challenge existing regimes. This dedicated work represents a challenging task, since different contexts, strategies, reflective work and considerations are at play in different phases. Our study case points to how protection strategies were crucial at the outset to challenge the inertia in planning practices, whereas community building and sharing strategies were crucial in order to transform the tacit and local knowledge into more context-free and generic knowledge.

A third clue is that more research is needed on the concrete dynamics involved in protecting and supporting adaptive approaches in order to improve our understanding of the more practical characters of transition processes in water management at the early stages. The study of a successful micro-transition has proven adequate to generate new knowledge about how specific actors succeed in overcoming resistance and dynamics of lock-in through practical efforts. More emphasis on research within this field would improve the understanding and guidance on how to implement adaptive solutions and approaches in urban water management in practice.

In terms of policy making, an important clue is that the complexity and practical character of local projects need to be taken into account, if the more adaptive solutions are to be implemented that challenge the established water management regime. This presupposes a greater commitment to engage in such processes of change. Moreover, it is important to point towards the need to supplement technical competences in water engineering with broader competences within the social and organizational field, in order for such key actors to be able to relate to the water system as a socio-technical whole.

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REFERENCES

Albrechts, L. (2006). "Bridge the gap: From spatial planning to strategic projects." *European Planning Studies*, 14(14), 1487–1500.

Brown, R., Ashley, R., and Farrelly, M. A. (2011). "Political and professional agency entrapment: An agenda for urban water research." *Water Resources Management*, 25(15), 4037–4050.

Brown, R. and Farrelly, M. A. (2009). "Delivering sustainable urban water management: A review of the hurdles we face." *Water Science and Technology*, 59(5), 839–846.

Brugge, R. and Rotmans, J. (2007). "Towards transition management of European water resources." *Water Resources Management*, 21(1), 249–267.

Burch, S., Sheppard, S. R. J., Shaw, A., and Flanders, D. (2010). "Planning for climate change in a flood-prone community: Municipal barriers to policy action and the use of visualizations as decision-support tools." *Journal of Flood Risk Management*, 3(2), 126–139.

Conklin, E. J. (2006). *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. John Wiley and Sons Ltd, West Sussex, United Kingdom.

Egedal Municipality (2011). *Sewage Plan 2011-2015*. Draft approved by the Egedal Municipal Council, Egedal, Denmark.

Farrelly, M. and Brown, R. (2011). "Rethinking urban water management: Experimentation as a way forward." *Global Environmental Change - Human and Policy Dimensions*, 21(2), 721–732.

Geels, F. and Deuten, J. J. (2006). "Local and global dynamics in technological development: A socio-cognitive perspective on knowledge flows and lessons from reinforced concrete." *Science and Public Policy*, 33(4), 265–275.

Geels, F. and Raven, R. (2006). "Non-linearity and expectations in niche-development trajectories: Ups and downs in dutch biogas development (1973-2003)." *Technology Analysis and Strategic Management*, 18(3-4), 375–392.

Geels, F. W. and Schot, J. (2007). "Typology of sociotechnical transition pathways." *Research Policy*, 36(3), 399–417.

Geldof, G. D. and Stahre, P. (2004). *Enhancing Urban Environment by Environmental Upgrading and Restoration*. NATO Science Series, Springer, New York, United States, Chapter The interaction between water and society - a new approach to sustainable stormwater management, 381–394.

Godden, L., Ison, R. L., and Wallis, P. J. (2011). "Water governance in a climate change world: Appraising systemic and adaptive effectiveness." *Water Resources Management*, 25(15), 3971–3976.

Hård, M. (1994). "Technology as practice - local and global closure processes in diesel-engine design." *Social Studies of Science*, 24(3), 549–585.

Kemp, R., Schot, J., and Hoogma, R. (1998). "Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management." *Technology Analysis and Strategic Management*, 10(2), 175–195.

Lee, K. N. (1999). "Appraising adaptive management." *Conservation ecology*, 3(2), 3.

Lim, B., Spanger-Siegfried, E., Burton, I., Malone, E. L., and Huq, S. (2005). *Adaptation Policy Frameworks for Climate Change: Developing Strategies,* *Policies and Measures*. Cambridge University Press, Cambridge, United Kingdom.

Mcginnis, M. D. (1999). *Polycentric Governance and Development: Readings from the Workshop in Political Theory and Policy Analysis*. University of Michigan Press, Michigan, United States.

Morison, P. J., Brown, R. R., and Cocklin, C. (2010). "Transitioning to a waterways city: Municipal context, capacity and commitment." *Water Science and Technology*, 62(1), 162–171.

Nielsen, S. B., Hoffmann, B., Quitzau, M. B., and Elle, M. (2009). "Mobilizing the courage to implement sustainable design solutions: Danish experiences." *Architectural Engineering and Design Management*, 5(1-2), 53–61.

Olsson, P., Gunderson, L. H., Carpenter, S. R., Ryan, P., Lebel, L., Folke, C., and Holling, C. S. (2006). "Shooting the rapids: Navigating transitions to adaptive governance of social-ecological systems." *Ecology and Society*, 11(1), article number 18.

Pahl-Wostl, C. (2002). "Towards sustainability in the water sector - the importance of human actors and processes of social learning." *Aquatic Sciences*, 64(4), 394–411.

Pahl-Wostl, C. (2007a). *Integrated Assessment of Water Resources and Global Change*. Springer, Chapter Transitions towards adaptive management of water facing climate and global change, 49–62.

Pahl-Wostl, C. (2007b). "Transitions towards adaptive management of water facing climate and global change." *Water Resources Management*, 21(1), 49–62.

Pahl-Wostl, C., Holtz, G., Kastens, B., and Knieper, C. (2010). "Analyzing complex water governance regimes: The management and transition framework." *Environmental Science and Policy*, 13(7), 571–581.

Pahl-Wostl, C., Kabat, P., and Möltgen, J. (2008). *Adaptive and Integrated Water Management: Coping with Complexity and Uncertainty*. Springer Berlin Heidelberg, Germany.

Pahl-Wostl, C., Sendzimir, J., Jeffrey, P., Aerts, J., Berkamp, G., and Cross, K. (2007). "Managing change toward adaptive water management through social learning." *Ecology and Society*, 12(2), article number 30.

Pearson, L. J., Coggan, A., Proctor, W., and Smith, T. F. (2010). "A sustainable decision support framework for urban water management." *Water Resources Management*, 24(2), 363–376.

Quitzau, M. B., Hoffmann, B., and Elle, M. (2012). "Local niche planning and its strategic implications for implementation of energy-efficient technology." *Technological Forecasting and Social Change*, 79(6), 1049–1058.

Raven, R. P. J. M., Verbong, G. P. J., Schilpzand, W. F., and Witkamp, M. J. (2011). "Translation mechanisms in socio-technical niches: A case study of dutch river management." *Technology Analysis and Strategic Management*, 23(10), 1063–1078.

Rip, A. and Schot, J. W. (2002). *Shaping Technology, Guiding Policy: Concepts, Spaces and Tools*. Edward Elgar Publishing, Cheltenham, United Kingdom, Chapter Identifying loci for influencing the dynamics of technological development.

Schluter, M., Hirsch, D., and Pahl-Wostl, C. (2010). "Coping with change: Responses of the uzbek water management regime to socio-economic transition and global change." *Environmental Science and Policy*, 13(7), 620–636.

Shove, E. (1998). "Gaps, barriers and conceptual chasms: Theories of technology transfer and energy in buildings." *Energy Policy*, 26(15), 1105–1112.

Stahre, P. (2006). *Sustainability in Urban Storm Drainage: Planning and Examples*. Svenskt Vatten, Stockholm, Sweden.

Stenløse Municipality (2001). *Municipal Plan 2002-2012*. Stenløse, Denmark.

Van Der Brugge, R. and De Graaf, R. (2010). "Linking water policy innovation and urban renewal: The case of Rotterdam, the Netherlands." *Water Policy*, 12(3), 381–400.

Wong, T. and Brown, R. (2009). "The water sensitive city: Principles for practice." *Water Science and Technology*, 60(3), 673–682.

Wong, T. and Eadie, M. A. (2000). "Water sensitive urban design-a paradigm shift in urban design." *Proceedings of the 10th World Water Congress*, Melbourne, Australia.