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Master's Thesis | David Kuhn

Successful joint knowledge production for sustainability

A framework developing approach
using wastewater reuse projects in Germany
as empirical testing field

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1 INTRODUCTION

1.1 SOCIETAL AND SCIENTIFIC RELEVANCE

Sustainability is a central and relevant topic for all societies in the 21st century. Current sustainability challenges – such as climate adaptation, post-fossil energy supply or water scarcity – are described as complex, dangerous and urgent by research. This is not because these adjectives are in vogue, but because they grasp most adequately the characteristics of sustainability issues (Haasnoot et al., 2013; IPCC 2014; Wiek et al., 2011). Given the complexity, danger and urgency of these challenges, their solutions appropriately appear to be non-linear and multi-dimensional: *"Solutions to sustainability problems are generally not simple technical fixes or command-control procedures; they are often as complex as the problems themselves […]"* (Wiek & Lang, 2016: 32).

With this premise, scholars, politicians and civil society actors have identified productive science-policy interactions – amongst other approaches such as bottom-up initiatives or transition management – as a promising field for the development of complex solutions for complex problems (Hegger et al., 2012; Lang et al., 2012; Wiek et al., 2011). One way to realise productive interactions between science and policy actors is the so-called *joint knowledge production* (JKP). As a research practice, JKP can be defined by a) the inclusion of various stakeholders of a certain problem who b) develop a mutual understanding of the problem dimensions and c) engage in the joint development of knowledge on how to solve the sustainability problem (Bremer et al., 2019; Hegger et al., 2012; Van Enst et al., 2014).

Such a broad understanding of JKP covers and makes applicable key characteristics shared by various research traditions situated at the boundaries of science and policy. Science and technology studies (STS), transdisciplinary research (TDR), mode-2 knowledge as well as post-normal science; they all call for new modes of knowledge production while operating with different ontological, epistemological and methodological ideas. STS is establishing itself as a singular research field that stems mainly from sociology and philosophy of technology

studies (see e.g. Lidskog & Sundqvist, 2015). TDR is understood both as a research field as well as a concrete research method for which directly applicable sets of principles and steps are suggested (see e.g. Pohl & Hadorn, 2007). Literature on mode-2 knowledge (non-hierarchal, interdisciplinary, inclusive knowledge production) and post-normal science (knowledge production under conditions of uncertainty, dispute and urgency) push the theoretical debate on science-policy interactions to fundamentally question the privileged role of science in the production of knowledge and truths in post-modern societies (Funtowicz & Ravetz, 1993; Gibbons et al., 1994). Despite the variations, all the theories, academic fields and approaches evolved in the past four to five decades out of Western academic and societal debates on environment-related risks and disasters, such as Chernobyl in 1986 or early reports on climate change. The theoretical foundations can be traced back to writings about the complex relationship between society and nature and the uneasy role of scientific knowledge production therein (e.g. Beck, 1986; Foucault, 1966; Horkheimer & Adorno, 1944). Within this broader debate, JKP offers a research practice that can be concretely applied on the project level while maintaining a certain degree of openness for different modes of how JKP is exactly realised. Consequently, TDR can be seen as one specific mode of JKP.

Given the above-mentioned relevance assigned to JKP for solving pressing sustainability challenges as well as its inherent openness, there is an ongoing debate on how to realise JKP successfully in a concrete empirical situation. Here, the increasing number of conducted JKP projects throughout the globe is accompanied by reflection articles in which participating researchers share their experiences on do's and don'ts. For example, Lang et al. (2012) aim for "providing good guidance" (Lang et al., 2012: 26) by suggesting an ideal-typical process of JKP consisting of three phases, namely framing the problem, co-creating knowledge and applying the developed knowledge. Similar to Lang et al. (2012), Pohl et al. (2010) base their findings on their own experiences made in JKP projects in various countries. By focusing on the role of researchers in such projects, they suggest power relations, differing perspectives and the promotion of a sustainable development orientation as three key challenges within JKP. Translating empirical experiences and conceptual work into suggestions for future attempts is

also the modus operandi of Pohl & Hadorn (2007), Fry et al. (2008), Angelstam et al. (2013), Mauser et al. (2013), Renner et al. (2013), Mattor et al. (2014), Winker et al. (2016), Esmail et al. (2017) Luthe (2017), Hoffmann et al. (2017), Riousset (2017), Mann & Schäfer (2018) or Nölting & Mann (2018).

With a growing body of empirical and conceptual literature on JKP, there is a growing potential for systematising, testing and specifying the various findings in order to make them useful – that is, applicable – for participants in future JKP attempts. In the words of Lang et al. (2012): "*a critical step will be to turn the proposed set of design principles, which is entirely based on the literature and personal experiences, into an evidence-based set of principles*" (Lang et al., 2012: 40). Investigations of climate change adaptation projects in the Netherlands by Hegger & Dieperink (2014) present one of the few efforts in which scholars make this critical step towards empirically testing design principles for successful JKP. Hence, further systematisation and testing are imperative so that existing knowledge can be applied in empirical situations for solving complex sustainability challenges.

1.2 RESEARCH OBJECTIVE AND QUESTIONS

In the light of the immense potential to further develop JKP as a research practice, the work presented here aimed to contribute to cumulative empirical insights on how to jointly produce knowledge for complex sustainability problems by developing, testing and specifying a practically applicable framework. Such a framework can be understood as the "conceptual infrastructure of situational analysis" (Clarke & Star, 2008: 114) as well as the *conceptual infrastructure for situational action* as it provides participants of JKP with a tool to identify both obstacles to and points of leverage for success in their respective projects. To reach this objective, the underlying research process was continuously steered by the question: **Which generalisable factors that increase the likelihood of successful joint knowledge production for sustainability can be developed from the empirical field of wastewater reuse projects in Germany?** Each research step necessary to find answers to this main question was guided by one or two specific sub-questions:

a) Which success criteria and success factors can be derived from existing literature on joint knowledge production?
b) To what extent do experiences from joint knowledge production projects on wastewater reuse in Germany confirm the success factors identified in literature and how can these experiences help to further specify certain factors and their potential contribution to success?
c) What degree of transferability do joint knowledge production experts from various empirical fields assign the findings based on wastewater reuse projects in Germany?

1.3 RESEARCH FRAMEWORK AND PAPER STRUCTURE

The research framework presented in figure 1 visualises how the success framework served both as objective *of* this research and boundary object *for* this research; the latter by being the platform incorporating the findings of the different research steps. The framework was nurtured by a) systematising success factors and success criteria derived from existing literature, b) testing and specifying these factors with empirical cases of JKP on wastewater reuse in Germany and c) validating the transferability of the empirically tested success factors in a workshop with experts working in various geographical contexts on different sustainability challenges.

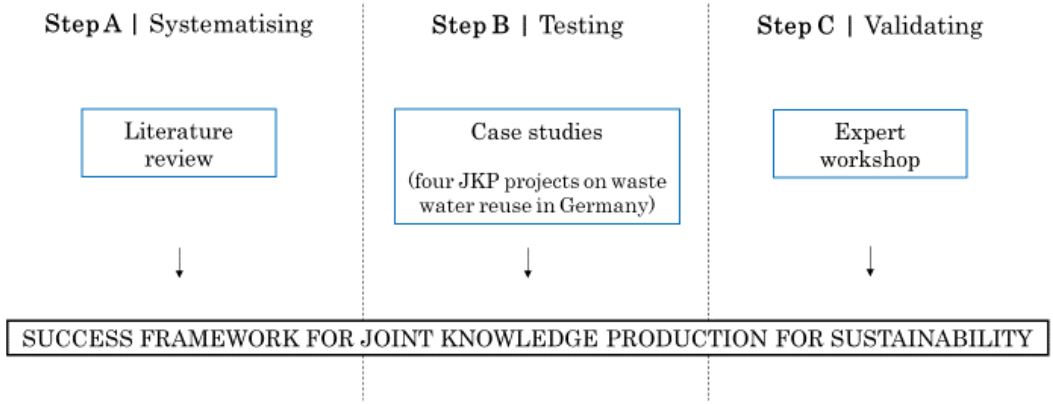

Figure 1: Research Framework

The presentation of the conducted research in this paper starts by suggesting a conceptualisation of *success* that acknowledges the non-linear character of JKP processes (chapter 2). In the same chapter, this conceptualisation is then merged into an analytical framework with success factors derived from a literature study. Chapter 3 outlines the methods and argues that interviewing participants from wastewater reuse projects in Germany is a promising approach for testing and specifying the initial framework. It is also explained how an expert workshop served as a complementary step for validating the findings. After the four cases are described in detail in chapter 4, the findings of the empirical confrontation are first presented per project, then compared and lastly summarized in the form of a revised framework (chapter 5). Chapter 6 argues that the framework is transferrable to other empirical domains when considering contextual factors. This paper is closed by discussing in chapter 7 the potential for further research given the limitations of the chosen approaches and by providing a final summary in chapter 8 of the contributions made with this research for solving complex sustainability challenges.

2 CONCEPTUAL RESEARCH DESIGN

This chapter presents answers to the first sub-question a) *Which success criteria and success factors can be derived from existing literature on joint knowledge production?* Firstly, a conceptual framework with a clear definition of JKP is provided in section 2.1. In section 2.2., findings from a literature review on success factors are then merged into an analytical framework for successful JKP to be tested empirically.

2.1 CONCEPTUAL FRAMEWORK

This research aims to build a success framework for JKP. Following the research objective stated above, the framework considers *successful joint knowledge production* as the dependent variable (section 2.1.1), and *success factors* as the independent variable (2.1.2). Figure 2 visualises the conceptual framework for this research.

As section 2.1.1 will elaborate, this work goes beyond conceptualisations of success that imply linear sequences of effectiveness such as output, outcome and impact. Instead, successful joint knowledge production is understood as a process in which a knowledge system is created that is perceived as salient, credible and legitimate by relevant stakeholders and that can therefore be expected contribute to effective problem solving. Consequently, success factors are understood as leverage points that increase the likelihood of a salient, credible and legitimate knowledge system (see section 2.1.2).

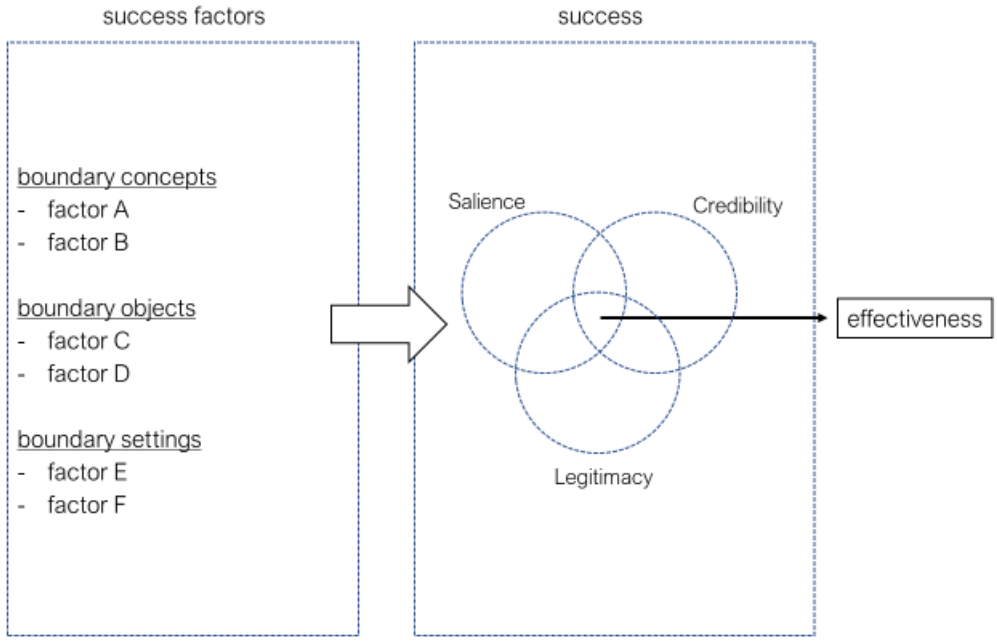

Figure 2: Conceptual Framework

In this research, success factors, success and the links between them were analysed. The assumed correlation between success and effectiveness was not part of the empirical evaluation.

2.1.1 Success

For this research, salience, credibility and legitimacy served as success criteria "by which success or failure of a project […] will be judged" (Cooke-Davies, 2002: 185).

In existing literature on successful JKP, a clearly defined and defended conceptualisation of success is often missing (e.g. Fry et al., 2008; Mauser et al., 2013; Mattor et al., 2014; Riousset, 2017). Most authors imply either a product- or a process-oriented understanding of success in their contributions. In product-oriented understandings it is suggested that "if successful, the process will result in joint problem solution, across science, technology, and society" (Angelstam et al., 2013: 256). Hence, Angelstam and others propose the effectiveness of the produced knowledge in solving a particular problem as the success criterion. Such a definition implies a measurable linearity between JKP and its effects. On the other hand, Pohl et al. (2010) point more at process conditions by suggesting that JKP is successful when it manages to include all the relevant perspectives. Consequently, the potential effectiveness of the knowledge produced is not discussed explicitly, which contrasts with the product-oriented understanding,

The research presented here follows a conceptualisation that manages to include both process-related concerns regarding the inclusion of perspectives, and product-oriented approaches that emphasise the need for knowledge that effectively leads to problem-solving. It is argued here that focusing solely on the process or on the product of JKP does not acknowledge the interdependence of process and product in attempts of JKP for sustainability. Theoretical and empirical evidence suggest that an inclusive JKP process increases the effectiveness and knowledge produced encompasses different ways of how to contribute to sustainable solutions. Hence, conceptualising an applicable success framework demands a definition of success that incorporates this interdependence between process and product in JKP. Consequently, this research follows a conceptualisation introduced by Cash et al. (2003) and applied in key contributions to successful JKP such as Lang et al. (2012), Hegger et al. (2012) and Hegger & Dieperink (2014). Here, it is suggested that attempts for joint knowledge production *"are more likely to be effective when they manage boundaries between knowledge and action in ways that simultaneously enhance the salience, credibility, and legitimacy of the information they produce" (Cash et al., 2003: 8086).*

Such an understanding of success has three major implications that are key to understanding the ways in which JKP can contribute to solving sustainability challenges. Firstly, it suggests information or knowledge is the key result of JKP. Thus, changing existing knowledge on a sustainability issue can contribute to its solution. Second, it is assumed that if the information produced meets the three criteria ***salience*** (relevance), ***credibility*** (applicability) and ***legitimacy*** (inclusiveness), it is more likely to be effective in problem-solving. Thirdly and importantly, whether the criteria are fulfilled or not depends on the perception of key stakeholders in a concrete JKP attempt and not on the evaluation of an *objective* assessor (Cash et al., 2003). Hence, effectiveness of the knowledge produced is deeply connected with the *what, for whom and how* of the knowledge. In other words, this conceptualisation rejects the idea of objective knowledge and instead suggests that knowledge production is a societal process in which voices can be either included or excluded. Excluding voices that are relevant to a certain issue is not only illegitimate but also lowers the chance of providing a solution that

takes into account the various dimensions of the issue at hand. To that point, Hegger et al. (2012) suggest that "all actors may have criteria related to all three concepts" (Hegger et al., 2012: 54). Thus, salience refers to the relevance of the information, indicating whether the information produced supports decision-making of all stakeholders involved, including practitioners[1] as well as scientists. Similarly, credibility is not limited to scientific adequacy, but whether the information produced within a process of JKP meets the particular epistemological standards of each stakeholder. And subsequently, high legitimacy demands the involvement of concerns and perspectives from all relevant stakeholders of the respective issue (Hegger & Dieperink, 2014; Hegger et al., 2012).

In regard to the second major implication that suggests that high salience, credibility and legitimacy increase the quality of the information produced and thus the overall success of a JKP process, it is essential to better determine what is meant by *information produced*.

Hegger et al. (2012) distinguish between process and product when evaluating the success criteria and focus on the former. Consequently, it reads that "*successful joint knowledge production can be defined as a process in which the actors involved have managed to maximize synergy and minimize trade-offs between salience and credibility of the knowledge produced as well as the legitimacy of the process*" (Hegger et al., 2012: 54). Cash et al. (2003) refer not only to information but also to knowledge systems when overcoming boundaries between science and practice. A knowledge system can be understood as the place in which JKP happens, thus an *arena* in which different types of knowledge are confronted with each other. For example, knowledge based on practical experience and knowledge based on quantitative models confront each other in a knowledge system (Felt et al., 2016). Hereby it is assumed that there is a pre-existing knowledge system characterized with low levels of salience, credibility and legitimacy and hence lacking

[1] In this work, the term *practitioner* refers to societal actors that work outside academia in e.g. private companies, municipalities or civil society organizations on a certain problem. Congruently, the term *practice* is used as opposed to academia.

effectiveness. JKP can thus be seen as a positive impetus to the existing knowledge system.

Based on the elaborations by Cash et al. (2003), Hegger et al. (2012) and Felt et al. (2016), the conceptualisation proposed in this research understands that JKP for sustainability is not as a linear sequence of isolated parts, but instead comprised of processes and products that are closely related. For example, the learning experience of a scientist by talking to a practitioner can be perceived as a *process* happening within JKP, as a concrete *output* as well as an *outcome* because the new knowledge might change the scientist's future behaviour. Consequently, the unit of analysis when assessing salience, credibility and legitimacy (thus success) was the knowledge system created within a process of JKP. This leads to the following definition of successful joint knowledge production:

A process of JKP in which a knowledge system is created that can be characterised by a simultaneously high degree of credibility, salience and legitimacy by relevant stakeholders is successful, and therefore can be expected to effectively contribute to solving a particular sustainability problem.

Thus, the research conducted looked at whether concrete projects have changed an existing knowledge system on a particular issue in such a way that it meets the three criteria. Figure 3 visualises how success serves as the dependent variable of the conceptual framework.

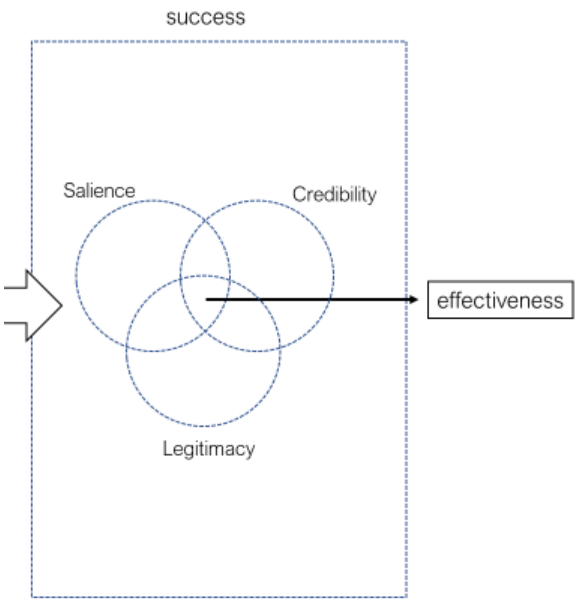

Figure 3: Dependent Variable

2.1.2 Success Factors

Success factors can be conceptualised as "those inputs by the management system that lead directly or indirectly to the success of the project" (Cooke-Davies, 2002: 185). Taking an interpretative approach, this research acknowledges the complexity and contingency of societal processes. Thus, it is both ontologically and epistemologically unlikely to define clear causal links between certain success factors and the success criteria. Instead, the framework developed in this research suggests that the presence of certain factors in a JKP process increase the likelihood of constructing a knowledge system that is perceived by all relevant stakeholders as salient, credible and legitimate. The following figure 4 visualises success factors as the independent variable for the conceptual framework.

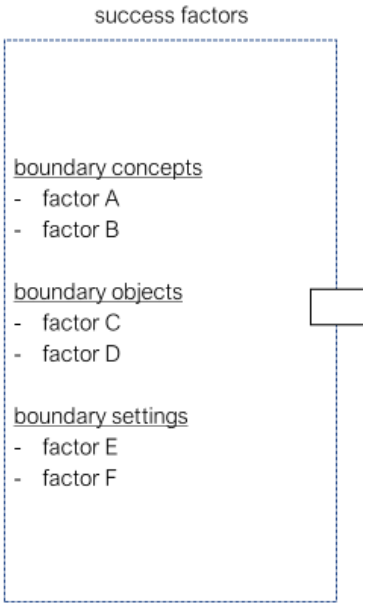

Figure 4: Independent Variable

Hereby, the concept of *boundary work* – work situated on the boundaries of science and society with its three dimensions: concepts, objects and settings – is used to distinguish different types of success factors. Mollinga (2010) developed this concept to make approachable the challenges that arise from the threefold complexity of research on natural resource systems: a) ontological complexity due to the heterogeneity of the systems and non-linear relations of its components, b) societal complexity due to the manifold and potentially conflicting concerns by various stakeholders and c) analytical complexity due to the difficulty to understand these systems intellectually given a) and b). Hence, he suggests three dimensions of boundary work:

i. "The development of suitable *boundary concepts* […] allow thinking, that is, conceptual communication about the multidimensionality of NRM [Natural Resource Management] issues.
ii. The configuration of adequate *boundary objects* as devices and methods […] allow acting in situations of incomplete knowledge, nonlinearity, and divergent interests.
iii. The shaping of conducive *boundary settings* in which these concepts, devices, and methods can be fruitfully developed and effectively put to work" (Mollinga, 2010: 4)

Using the three boundary dimensions suggested by Mollinga (2010) to categorize success factors was beneficial for two reasons. Firstly, it facilitated the synthesis findings derived from literature into concrete factors. Here, the categorisation alongside boundaries matches well with the *knowledge system* conceptualisation developed in 2.1.1 and avoids the inadequate framing of JKP as a linear sequence of different steps leading to effectiveness. Such a risk is arguably present when using categorisations for success factors such as *steps* or *phases* as done by Pohl et al. (2010) or Lang et al. (2012). Furthermore, many articles included in the synthesis suggest boundary objects as potential success factors (Hegger & Dieperink, 2014; Lang et al., 2012; Luthe, 2017; Pohl et al., 2010), and Mattor et al. (2014) apply the three dimensions to analyse their own experiences in JKP. This facilitated the synthesis enormously. On the other hand, the typology supported in the empirical confrontation the detection of potential patterns among the different factors as well as between factors and criteria. For example, whether a certain setting (e.g. funding structure) facilitates the presence of a certain boundary object (e.g. usable product for all). Thus, introducing the boundary-approach also allowed the latter specification of the factors derived from literature – a key objective of this research.

2.2 ANALYTICAL FRAMEWORK

Based on the conceptual framework for this research, the first analytical step was to fill the framework with success factors extracted from relevant literature. Doing

this resulted in the construction of an initial analytical or explanatory success framework for JKP which is presented in section 2.2.3 (figure 5).

2.2.1 Integrative literature review

To build up an initial success framework, the literature review focused on scientific articles that present insights on how to do successful JKP for sustainability. When synthesising the various findings, an integrative approach was applied in acknowledgement that it should "*result in the advancement of knowledge and theoretical frameworks, rather than in a simply overview or description of a research area. That is, it should not be descriptive or historical but should preferable generate a new […] framework […]*" (Snyder, 2019: 336).

Hence, only those findings that potentially had explanatory power for ensuring salience, credibility and/or legitimacy of the knowledge system produced were extracted from existing studies on successful JKP. These findings where then synthesised in two ways: Firstly, congruent findings were brought together under a single explanatory factor. Secondly, the different explanatory factors developed were categorised and collected in an overarching list of factors. Hereby, boundary concepts, objects and settings served as the general structure.

Every factor suggested in relevant literature was included that could be related to increasing salience, credibility and/or legitimacy. Thus, there was no pre-assessment done by choosing the most powerful explanatory findings. As argued in the introductory chapter, many articles base their findings on normative, conceptual or very limited empirical considerations. Consequently, this research was driven by the need to empirically test and specify the findings from literature. In other words, if it had been possible to already differentiate more and less powerful explanatory variables based on findings in literature, this research would be redundant.

2.2.2 Findings

Sixteen articles were identified as sharing relevant insights on how to make JKP successful. As explained in section 2.1.1. not all articles provide a clear conceptualisation of *success* when suggesting principles, steps, factors or

conditions to increase the likelihood of success. However, the findings of the sixteen articles included in this step could all be assumed to contribute to a high degree of salience, credibility and/or legitimacy (see table 1 in section 2.2.3). This section presents all success factors derived from literature categorised under the three dimensions of boundary work (Mollinga, 2010). For each factor, a definition is suggested (indicated with "→") and the empirical context it was derived from is explained.

Boundary concepts

The following factors were categorised as boundary concepts, including non-physical terms, definitions, visualisations or the alike, that facilitate the communication within a process of JKP (Mollinga, 2010).

Acknowledgement of differences

> → Explicit recognition by all participants within a particular JKP process that the different stakeholders may have a different understanding of the problem, the solution and differing reasons to be concerned.

Pohl et al. (2010) when reflecting on sustainability research in Kenya, Switzerland, Bolivia and Nepal as well as Hegger & Dieperink (2014) on JKP for climate change adaptation in the Netherland emphasise the need of acknowledging the different and contradictory perspectives that come together in such projects.

Balanced problem ownership

> → All participants can bring in their specific concerns and nobody is dominating the process.
>
> Lang et al. (2012) identified unbalanced problem ownership as a key challenge in various transdisciplinary research projects conducted in Europe, North America, South America, Africa and Asia. Luthe (2017) confirmed this with experiences made in projects on mountain communities in colder climates.

Clear role distribution

→ Every participant is aware of what his or her own task is to contribute to the project goals.

Pohl et al. (2010), Lang et al. (2012), Hegger & Dieperink (2014) and Luthe (2017) suggest this factor based on experiences in various sustainability projects in geographical contexts all over the world. To facilitate a clear role distribution, Nölting & Mann (2018) suggest multi-actor guiding frameworks based on experiences made in water reuse projects in Germany.

Joint goal definition

→ The participants communicate about and agree on an objective to be reached within the JKP process.

Pohl et al. (2010), Lang et al. (2012), Angelstam et al. (2013), Mauser et al. (2013), Hegger & Dieperink (2014), Winker et al. (2016), Hoffmann et al. (2017), Luthe (2017) and Riousset (2017) highlight the need to avoid a situation in which different participants have different ideas of the goals to be reached. This can be a major obstacle to develop knowledge that considers the various dimensions of the problem. Their findings are based on regionally bound sustainability and transdisciplinary research on climate change adaptation projects or water as well as on an international initiative on global sustainability research, green infrastructure programmes under the EU Horizon 2020 programme and political consulting on future land use in Great Britain.

Joint problem definition

→ In an interplay with the joint goal definition, the participants communicate about what they see as the problem to be solved and formulate a problem definition that respects all the different concerns.

Pohl et al. (2010), Lang et al. (2012), Angelstam et al. (2013), Mauser et al. (2013), Hegger & Dieperink (2014), Hoffmann et al. (2017), Luthe (2017) all suggest explicitly or implicitly joint problem definition as an important factor in realising successful JKP. Their findings are based on regionally

bound sustainability projects as well as on an international initiative on global sustainability research and green infrastructure projects under the EU Horizon 2020 programme.

Boundary objects

The following factors were categorised as boundary objects, including material objects or human subjects, that allow acting within a JKP process by offering points of contact for the different contributions of different actors (Mollinga, 2010).

Material boundary objects[2]

→ Material objects or devices that are graspable and foster the different participants to contribute components that make the overall object complete or working.

Pohl et al. (2010), identified a boundary object as supportive for the integration of different interests in sustainability research in Kenya, Switzerland, Bolivia and Nepal. Lang et al. (2012), Hoffmann et al. (2017) and Luthe (2017) confirm this with findings derived from transdisciplinary research projects conducted in Europe, North America, South America, Africa and Asia. Hegger & Dieperink (2014) identified e.g. "meeting tables in the shape of the map of the province" (Hegger & Dieperink, 2014: 10) serving as boundary objects in climate change adaptation projects in the Netherlands.

Facilitators[3]

→ Participants within the project that mediate between different perspectives, solve conflicts, coordinate tasks or make decisions in critical moments. These facilitators can be either officially assigned for such role or assume this function more informally.

[2] In this synthesis, boundary objects are both used as a typology of factors and as a concrete factor.

[3] In literature, the idea of boundary objects is usually restricted to non-human things. Here, *facilitators* acting as boundary persons are also brought under this category as they arguable fulfil a similar role: they channel the different contributions into action steps.

Based on experiences made in a working group on knowledge sharing within the Swiss Academic Society for Environmental Research and Ecology, Fry et al. (2008) highlight the need for intermediary actors to translate between different epistemes that meet in attempts of JKP. Pohl et al. (2010) and Angelstam et al. (2013) present similar findings when reflecting on a variety of sustainability projects aiming for JKP in different parts of the world.

Reward products for all

→ Concrete material or immaterial things that translate the results in products that are perceived as useful in the respective working contexts of different participants.

Lang et al. (2012) identified the relevance to generate products for both researchers and practitioners in sustainability projects across different world regions. Hegger & Dieperink (2014) emphasise this by pointing at the need to develop innovative reward structures apart from e.g. publications that often only serve researchers as rewards. Renner et al. (2013) confirm the need of clear benefits based on sustainable water governance projects conducted in Austria and Switzerland.

Boundary settings

The following factors were categorised as boundary settings, including the number of participants or evaluation procedures, that allow a fruitful context in which the boundary concepts and objects can be developed (Mollinga, 2010).

Accountability

→ Basic level of responsibility for the project that is shared among all participants.

Riousset (2017) suggests the need for explicit accountability from all participants to bring projects such as on future land use in Great Britain to a successful end. This is confirmed by Winker et al. (2016) for the context of integrated water research in Germany and Renner et al. (2013) for sustainable water governance projects conducted in Austria and Switzerland.

Balanced power relations

→ Given that different participants have different levels of resources, authority or leverage in different contexts, nobody should have a disproportionately high influence within a JKP process.

Pohl et al. (2010) detected in sustainability projects in Kenya, Switzerland, Bolivia and Nepal the challenge to address existing power relations. Renner et al. (2013) confirm this based on sustainable water governance projects conducted in Austria and Switzerland.

Broad actor coalition

→ An actor coalition that brings together all relevant stakeholders while not exceeding a manageable number of participants.

Lang et al. (2012), Mauser et al. (2013), Angelstam et al. (2013), Hegger & Dieperink (2014) and Renner et al. (2013) put special emphasis on the necessity to form a team that includes the relevant stakeholders to incorporate the different dimensions of the problem at hand. This finding is based on experiences made in sustainability projects in different countries worldwide, an international initiative for global sustainability research, green infrastructure projects within the EU Horizon 2020 programme and climate change adaptation projects in the Netherlands.

Continuous participation

→ All relevant stakeholders are involved and present throughout the JKP process.

Lang et al. (2012) saw a high fluctuation of participants as a key obstacle for successful JKP in sustainability projects on various continents.

Evaluations procedures

→ Formative evaluation throughout the JKP process in order to identify and address unexpected or undesired developments.

Lang et al. (2012), Angelstam et al. (2013) and Hoffmann et al. (2017) identified ongoing evaluation in sustainability projects worldwide as a key

factor that allows to keep the overall process on track. Mann & Schäfer (2018) highlight evaluation as important in transdisciplinary research processes in Germany given the "changing context conditions" (Mann & Schäfer, 2018: 216).

Flexibility

→ Flexibility in time, content and methods throughout the JKP process to adjust to unexpected or undesired developments.

Winker et al. (2016) and Mann & Schäfer (2018) identified this factor as key for water research in Germany and are confirmed by Luthe (2017) reflecting on transdisciplinary research projects in Russia, Norway and the Alps.

Funding

→ Secured funding throughout the process.

Mattor et al. (2014) identified unsecured funding as a major obstacle in environmental governance projects in the Intermountain West region of the United States. Luthe (2017) specifically emphasises the need for quickly available initiation funding based on experiences made in transdisciplinary research projects in Russia, Norway and the Alps.

Informal exchange

→ Communication among the participants beyond the formal channels.

Fry et al. (2008) as well as Angelstam et al. (2013) formulated informal exchange as a key factor to facilitate JKP when reflecting on a working group on knowledge sharing within the Swiss Academic Society for Environmental Research and Ecology respectively on green infrastructure projects in the EU.

Productive conflict

→ Controversial yet respectful discussions among the participants about the problem, solutions or the process.

Pohl & Hadorn (2007) suggest this as a key principle for transdisciplinary research projects on sustainability.

Project initiation by society

→ The initiation of a JKP project is steered by actors from society and not from academia.

Luthe (2017) identified this as one way to avoid major obstacles like imbalanced problem ownership based on transdisciplinary research projects in Russia, Norway and the Alps.

Recursiveness

→ Repeating key steps within a JKP process to ensure adaptiveness to new developments.

Pohl & Hadorn (2007) and Mann & Schäfer (2018) suggest this as a key principle for transdisciplinary research projects on sustainability.

Trustful collaboration

→ The participants can rely on each other's support.

Reflecting on knowledge co-production on a watershed in Lower Saxony, Germany, Esmail et al. (2017) see trust as key for successful processes. Renner et al. (2013) confirm this based on sustainable water governance projects conducted in Austria and Switzerland.

2.2.3 Initial Success Framework

Incorporating the findings from the literature review into the conceptual framework developed in section 2.1 produced an analytical framework for successful JKP to be tested empirically (figure 5).

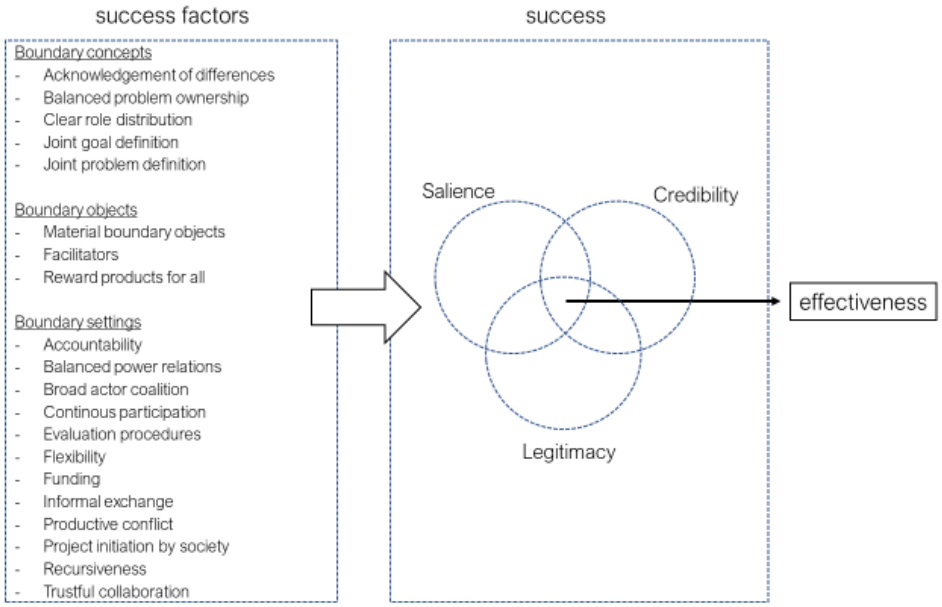

Figure 5: Initial Success Framework

This framework can be seen as the starting hypothesis of this research. It assumes that the presence of one or many success factors in a particular JKP process increases the likelihood of salience, credibility and/or legitimacy of the knowledge system created. A high degree of these three success criteria is then expected to contribute to effective problem solving.

When synthesising the findings from literature, potential ontological and epistemological differences were acknowledged but not problematized (Cairney, 2013). The conceptualisation of the success framework developed in section 2.1 explicitly assumes that different stakeholders of JKP have different ontological and epistemological standards in regard to salience, credibility and legitimacy.

One of the few efforts in which concrete links between particular success factors and success criteria were suggested can be found in Hegger et al. (2012) who make such assumptions for JKP in regional climate adaptation projects. Table 1 brings together the assumptions made by these scholars with assumptions made specifically for this research. For some factors, assumed relations with all three success criteria (salience, credibility, legitimacy) could be formulated while others seem to rather contribute to one particular criterion. The assumptions made here were evaluated empirically with the findings from the case studies (see section 5.3.3).

Table 1: Links between Success Factors and Success Criteria

Factors	Salience	Credibility	Legitimacy
Boundary concepts			
Acknowledge-ment of differences			↑ pre-condition for inclusion of different perspectives
Balanced problem ownership			↑ prevents dominating actors
Clear role distribution	↑ avoids conflicts that lower the quality of the results	↑ avoids conflicts that lower the quality of the results	↑ avoids that participants fall behind
Joint goal definition	↑ ensures relevance of the knowledge for different participants	↑ ensures applicability of the knowledge for different participants	
Joint problem definition	↑ ensures relevance of the knowledge for different participants	↑ ensures applicability of the knowledge for different participants	
Boundary objects			
Material boundary objects			↑ facilitate inclusion of different perspectives
Facilitators			↑ facilitate inclusion of different perspectives
Reward products for all	↑ ensures relevance of the results for different participants		
Boundary settings			
Accountability	↑ ensures that each participant contributes at least what is necessary to reach a certain level of relevance for all		

Balanced power relations			↑ prevents dominating actors
Broad actor coalition	↑ facilitates representation of relevant perspectives to reach salience for all in the first place ↓ too much participants can make the process very complex	↑ facilitates representation of relevant perspectives to ensure credibility in the first place ↓ too much participants can make the process very complex	↑ ensures representation of different perspectives in the first place ↓ too much participants can make the process very complex
Continuous participation	↑ facilitates a basic level of salience for all		
Evaluation procedures	↑ ensures relevance of results throughout the process	↑ ensures applicability of results throughout the process	↑ ensures inclusion of different perspectives throughout the process
Flexibility	↑ facilitates a basic level of salience for all		
Funding			↑ ensures continuous inclusion of different perspectives
Informal exchange			↑ adds another channel for including perspectives
Productive conflict	↑ can increase the relevance by debating the key issues		
Project initiation by society			↑ ensures the inclusion of non-academic perspectives
Recursiveness	↑ can increase the quality of the results and thereby their relevance	↑ allows to shift the focus throughout the project to ensure applicability for all	

3 TECHNICAL RESEARCH DESIGN

Presenting a theory-developing and -testing effort, this research presented here aimed for the empirical validation and specification of the initial success framework (see section 2.2.3). As indicated by the research framework (figure 6), this was done in two steps (B and C).

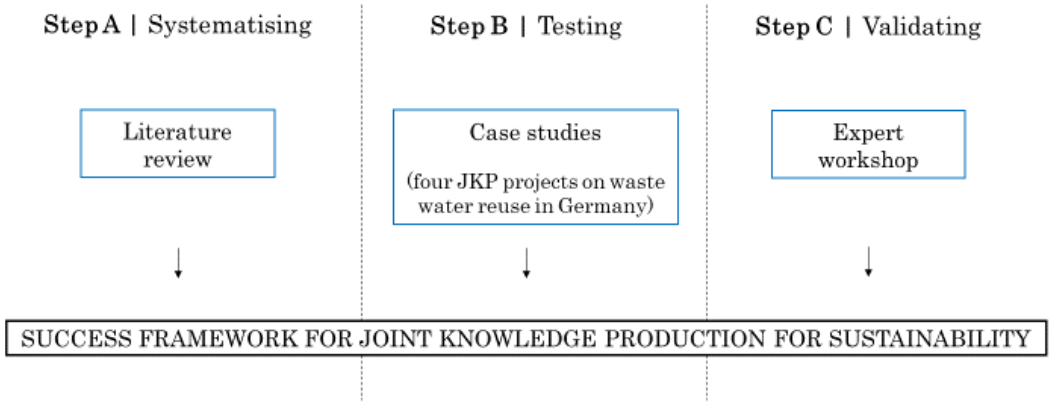

Figure 6: Research Framework (copy of figure 1)

Firstly, four cases of JKP on wastewater reuse in Germany were analysed in order to confirm, specify or reject the initial success framework build up with relevant literature. In a complementary effort, an expert workshop with experienced researchers and practitioners for JKP was organised to ensure the transferability of the findings based on the case studies to other empirical domains.

Section 3.1 explains in detail the selection of projects, operationalisation of variables as well as the data collection and processing for the case studies. In section 3.2, the selection of participants, operationalisation of variables as well as data collection and processing for the expert workshop are described.

3.1 CASE STUDIES

Choosing a small-n case study allowed an in-depth comparison among the different cases and thereby the detection of generalisable findings as well as the specification of which factor can contribute when and how to success (Verschuren & Doorewaard, 2010). To answer best sub-question b) *To what extent do*

experiences from joint knowledge production projects on wastewater reuse in Germany confirm the success factors identified in literature and how can these experiences help to further specify certain factors and their potential contribution to success? the following methodological choices were made.

3.1.1 Case selection

Confronting the success framework with experiences made in projects that all worked on the same sustainability problem – wastewater reuse – in the same geographical context – Germany – allowed to evaluate the internal validity of the success framework. That is focusing on project-internal differences and eliminating contextual factors as explanatory variables. Wastewater reuse in Germany was chosen as empirical testing field can be seen as illustrative for challenges JKP projects also face in other empirical domains. Winker et al. (2016) argue:

"Generally speaking, problems and challenges [of sustainability research] do not conform to the same boundaries as scientific disciplines or subjects. This also applies to the challenges faced by the German water sector today. As a result, it is often impossible for a single discipline to identify a solution within problem-oriented research. Instead, an interdisciplinary or even transdisciplinary effort is required to develop strategies and concepts as the best way forward [for the German water sector]" (Winker et al., 2016: 1).

The need to tackle challenges within the German water sector with cross boundary approaches such as JKP arises from various factors:

1. Responsibilities and competencies regarding water issues – including wastewater – in Germany are fragmented and therefore require a high degree of vertical and horizontal coordination among different political and legal levels. Being a federal republic, each German Federal State, *(Bundesland)* develops water guidelines that are complementary to national laws. Furthermore, different public authorities responsible for water *(Wasserbehörden)*, act on the Federal State level, district level *(Regierungsbezirke)* and area level *(Landkreise)* (Kuhn, 2014).

2. Different types of water use, such as for transport, drinking water, or biodiversity, often overlap and therefore include many different stakeholders like "scientists, water managers, farmers, landscape planners, local authorities, and environmental groups" (Esmail et al., 2017). Hereby, the traditionally technocratic approach to (waste)water management in Germany is currently challenged by an increasing number of socially and ecologically sensitive stakeholder groups (Kluge et al., 2006).
3. Climate change and land-use change pose significant challenges to quality and quantity of surface and groundwater in Germany. Also, the amount of fertilisers, medicine residues and other chemical or biological particles in wastewater is increasing (Winker et al., 2016). On top of this, Germany has high quality standards regarding drinking water (Kuhn, 2014). In consequence, highly thorough and effective ways to process wastewater are needed to meet the high (future) demand in quality and quantity.
4. Water is a cross-cutting theme through other sustainability domains such as "*climate change, demographic change, micropollutants, the energy turnaround and energy sufficiency, resource efficiency, technological change, [or] the state of ecology today*" (Winker et al., 2016: 1). Thus, every problem-solving effort needs to be open-minded.

Given these characteristics, projects aiming for concrete solutions for wastewater reuse in Germany provide a rich and representative testing field for success factors for JKP. Arguably, also other sustainability challenges in other geographical contexts would have been worth studying in regard to JKP as they share similar characteristics. Various reasons led ultimately to choose water in Germany. Firstly, four out of the sixteen articles used to build up the initial success framework focus on this empirical domain. This indicates that JKP is very common approach for solving water issues in Germany and therefore empirical insights are especially valuable here. Furthermore, water scarcity is a relatively new issue for middle-European countries such as Germany and consequently a broad societal and scientific debate is recently developing on how to reuse wastewater (Rohn et al., 2018). Hence, contributing insights on this particular issue is a very current undertaking. A third reason for water and against e.g. climate adaptation – a topic

that is also very pressing and present – is that Hegger & Dieperink (2014) contributed here already a first thorough testing of success factors. Thus, while many empirical domains appeared adequate for testing the initial success framework, the context of wastewater reuse in Germany suggested itself as the most suitable for this particular research.

Among the various existing projects aiming for JKP in the domain of water in Germany, four concrete projects were chosen for the case studies. Table 2 provides a brief overview of each project.

Table 2: Cases

Project	Focus	Life span
HighCon	Reuse of water and concentrates from industrial wastewater http://www.highcon.de/	September 2016 – December 2019
HypoWave	Water reuse for plant breeding http://www.hypowave.de/projekt/	September 2016 – January 2020
MULTI-ReUse	Modular treatment for diverse water reuse applications https://water-multi-reuse.org/	September 2016 – January 2020
REMEMBER	Advancement of membrane technologies for filtering wastewater http://www.remember-projekt.de/	September 2016 – December 2019

Being embedded in a state-funded programme named *Future-Proof Technologies and Concepts to increase the water availability through water reuse and desalinisation* (WavE), all four projects had a life span from 2016 until 2019 or 2020. Consequently, the projects worked in a very similar funding-setting, which further allowed focussing on project-internal factors such as the ones suggested in the initial success framework. Also, the fact that the official project life spans ended very recently allowed a retrospective evaluation while the experiences were still *fresh*. Furthermore, it was beneficial that all projects within the WavE-programme had a website with helpful information and contact details of the

respective coordinators. Lastly, all projects within the WavE-programme aimed to contribute to sustainable development and chose explicitly a JKP approach by involving actors from science and practice.

While being embedded in a similar context, especially the four chosen projects differed in key project-internal characteristics such as the number of participants (see chapter 4 for detailed project descriptions). This facilitated the explanation of potential differences in success with varying (project-internal) success factors being present.

Figure 7 shows where the four projects were located in Germany.

Figure 7: Case Locations

(derived from https://www.bmbf-wave.de/1466.php, 27th August 2020)

3.1.2 Operationalisation

Both the dependent variable – success – and the independent variable – success factors – were measured upon the perception of participants of a particular project.

In contrast to a standardised set of indicators, such an approach allowed to grasp *subjective* indicators for the success criteria. As explained in chapter 2, this research assumes that only if all stakeholders see the produced knowledge as salient, credible and legitimate, effectiveness can follow. However, operationalising success in such an open manner produces the risk of valuable information getting lost when participants did not perceive something as relevant to mention. Also, an imprudent selection of whom to talk to can produce a bias. To avoid this, careful choices regarding data collection and data processing were needed (see section 3.1.3).

The dependent variable success was measured by translating the individual success perceptions into one score for each success criterion per project ranging from "---" (very low degree) to "+++" (very high degree). Thus, "+++" was only assigned when all participants agreed that a certain criterion was fulfilled to a very high degree and "---" if all participants assigned a very low degree. Table 3 illustrates the scoring procedure for success in a fictive project X.

Table 3: Exemplified Scoring Procedure for Success

Participant	**Credibility**	**Salience**	**Legitimacy**
A	High degree	High degree	Very low degree
B	Generally yes	High degree	Generally yes
C	Very low degree	High degree	Rather not
Overall score	*+*	*+++*	*-*

The relevance of each factor suggested in the initial framework for reaching the potential success was measured by assigning individual scores from 0 (not mentioned or not relevant) over + (somewhat relevant) to++ (very relevant) for statements from each participant. Hereby, the presence of a factor was a necessary but not sufficient condition for its relevance for success. The comparison of the scorings of each success factor per participant allowed then to draw conclusions

about whether a particular factor was relevant for a potential success. Table 4 illustrates the scoring procedure for the success factors.

Table 4: Exemplified Scoring Procedure for Success Factors

Participant	Factor Y	Factor Z	Factor A
A	++	0	++
B	0	0	++
C	+	0	++
Overall score	*somewhat relevant*	*Not relevant*	*Highly relevant*

Even though the idea of drawing linear causal relationships between success and certain factors is rejected in this research, the scorings were necessary to allow a comparison among the different projects and to make subsequent conclusions about whether a certain success factor suggested in the initial framework was confirmed as being relevant.

3.1.3 Data collection and processing

In total, 12 semi-structured interviews were conducted. The supporting questions in the interview guide (see annex II) were structured alongside three objectives:

1. Investigate the extent to which the knowledge system created meets the success criteria salience, credibility and legitimacy.
2. Investigate the extent to which certain success factors of the initial framework were relevant for success.
3. Investigate the extent to which further factors were relevant for potential success.

Hereby, the general strategy was to make the interviewees talk about whatever seemed relevant to share about success from their perspective instead of pre-determining their answers with suggestive questions (Verschuren & Doorewaard, 2010). The interviewees were understood as representing the perspective of their particular institution that participated in the project.

Balancing out feasibility and representativeness, at least one scientific actor and one practitioner – a representative of a company, civil society organisation or

public institution – were interviewed per project. All interviews were conducted in German via telephone or videocall. Annex I provides an anonymised list of all interviews conducted.

When contacting the interviewees, they were informed about the objective of this research and whether other participants from their projects were also interviewed. Furthermore, before starting the interviews, approval was requested for recording the interview and for using the content in an anonymised form in this research (see annex III).

To process the acquired data, each interview was summarised and inserted into NVivo12, a software facilitates the analysis of documents, interviews and websites. Here, the summaries were analysed in an interpretative manner by coding certain statements with the different success criteria and factors from the initial framework. Thus, the approach can be best described as inclusive (but not bottom up) coding. This was necessary as the interviewees barely mentioned explicitly success criteria or success factors and also due to the fact that the interviews were conducted in German while the success framework was built up in English. Table 5 presents the codes used to analyse the success of the projects while table 6 shows the codes applied to analyse the relevant success factors. The latter table distinguishes between deductively derived codes from the initial framework and inductively derived codes based on the analysis.

Table 5: Coding Success

Codes used in NVivo	Number of interviews associated with the code
Salience (statements about relevance of the JKP process and its results)	12
Credibility (statements about applicability of the JKP process and its results)	11
Legitimacy (statements about inclusiveness of the JKP process and its results)	12
Other[4]	8

[4] Success criteria besides salience, credibility and legitimacy mentioned by interviewees were not relevant for scoring success in this analysis. However, these statements were also coded to later reflect on the strength and weaknesses of the success criteria (see chapter 7: Discussion).

Table 6: Coding Success Factors

Codes used in NVivo		Number of interviews associated with the code
Deductively derived from framework		
	Boundary Concepts	
	Acknowledgement of differences	8
	Balanced problem ownership	0
	Clear role distribution	3
	Joint goal definition	9
	Joint problem definition	9
	Boundary Objects	
	Material boundary objects	7
	Facilitators	9
	Reward products for all	4
	Boundary settings	
	Accountability	7
	Balanced power relations	0
	Broad actor coalition	9
	Continuous participation	4
	Evaluation procedures	5
	Flexibility	3

	Funding	0
	Informal exchange	5
	Productive conflict	2
	Project initiation by society	3
	Recursiveness	0
	Trustful collaboration	3
Inductively derived		
	Anticipatory project planning	2
	Bilateral exchange	5
	Previous collaboration	4

Annex IV provides an example screenshot of a coded interview summary showing how codes were assigned to key statements of an interview.

3.2 EXPERT WORKSHOP

Complementary to the case studies, an expert workshop was conducted to answer the sub-question c) *What degree of transferability do joint knowledge production experts from various empirical fields assign the findings based on wastewater reuse projects in Germany?* While the case studies aimed for a most similar context design, the expert workshop brought in expertise made in a variety of empirical domains in order to evaluate the external validity of the framework.

3.2.1 Selecting the participants

Balancing out the need for a wide range of contexts being represented while still allowing an in-depth discussion, six experts for JKP were invited to the workshop. All the participants have a demonstrated history of work experience on the

boundaries of science and society. Furthermore, and despite the fact that all experts were based in the Netherlands when the workshop took place, most participate regularly in JKP in various Global North and Global South countries. Their fields of expertise range from climate adaptation, food systems, shared resources to sustainable cities. Table 7 presents each expert briefly.

Table 7: Participants Expert Workshop

Name	Profession	Focal Area
Dhanush Dinesh	Global Policy Engagement Manager at CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and PhD candidate at Utrecht University	Science-policy engagement for climate action in food systems
Dries Hegger	Assistant Professor for Environmental Governance at Utrecht University and co-author of a book on JKP[5]	Regional water and climate governance
Femke Merkx	Researcher & Consultant for knowledge co-creation at Kenniscocreatie, onderzoek & advies and co-author of two books on JKP	Facilitation of joint knowledge production
Frank van Laerhoven	Assistant Professor for Environmental Governance at Utrecht University and former consultant at the Food and Agriculture Organization of the United Nations (FAO)	Collective action and shared resources
Madelon Eelderink[6]	Founder of and Participatory Action Researcher at 7Senses and PhD candidate at Utrecht University	Participatory Action Research for sustainability
Ymkje de Boer	Consultant for knowledge sharing at YMBA Kennis and co-author of a book on JKP	Sustainable cities

[5] Hegger, D., de Boer, Y., Offermans, A., Merkx, F., Dieperink, C., Kemp., R., van Lente, H., Cörvers, R. (2013): Kenniscocreatie naar productieve samenwerking tussen wetenschappers en beleidsmakers [English: Knowledge co-production for productive collaborations between scientists and policymakers]

[6] Madelon Eelderink did not participate in the workshop itself but joined a bilateral meeting in which the same content was discussed.

3.2.2 Operationalisation

To provoke a controversial but focused discussion, the findings about the success factors derived from the case studies were presented to the experts in the form of ten generalised recommendations. These recommendations were formulated in a way as if they could be directly applied to any JKP projects on sustainability. For example, recommendation 1 reads as follows:

A project leader (or intermediary actors) that is skilled in trans/interdisciplinary work and/or knows about the different subjects of the project is a relevant factor to increase the likelihood of success (defined in terms of salience, credibility and legitimacy).

The experts were then asked to evaluate the transferability of each recommendation to the type of projects they are familiar with.

3.2.3 Data collection and processing

The one-hour long workshop was organised as a recorded videocall and used the software Mural to facilitate the discussion. A few days before the actual workshop, all participants received the link for the digital whiteboard Mural on which the findings from the case studies were presented in detail. Also, the agenda of the workshop and the participating experts were briefly introduced here.

The workshop itself started with a brief recap of the content presented on Mural. The experts were then asked to react to the recommendations by using stickers in order to express their (dis)agreement regarding the transferability. Figure 8 gives an idea of how Mural was used in the workshop.[7]

[7] Annex VI provides screenshots of the Mural page covering all the content that was prepared for and added during the workshop.

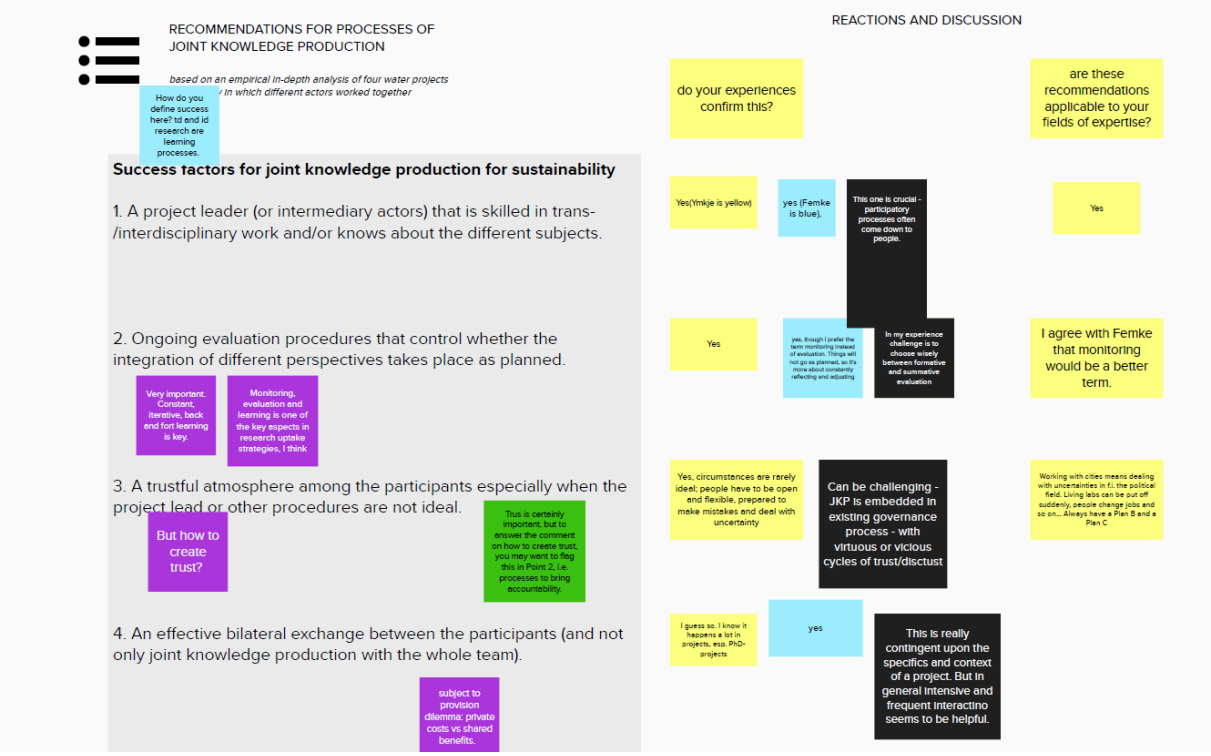

Figure 8: Digital Whiteboard in Expert Workshop

After this silent discussion, each expert was invited to make a verbal statement sharing their general impression of the recommendations and their thoughts on one specific recommendation. This round then let to a discussion in which several key obstacles to successful JKP and factors to overcome these were identified. The workshop was closed with a last round in which every expert shared his or her key learning from the past hour.

All participants agreed on the use of the videocall discussion and the content shared in Mural in this research (annex V). Furthermore, the participants could decide on whether their full name appeared in this report. The collected data was processed in an interpretative analysis that lead to various revisions of the framework based on the case studies (see chapter 6).

4 CASE DESCRIPTIONS

This chapter introduces the four investigated cases in detail. The information given here provide the context for the research findings outlined in chapter 5. General information presented in tables cover which stakeholders participated in each project, who was interviewed and where the project was located geographically. This is then followed by descriptions of the specific goals and steps of each project. As explained in section 3.1.1, all projects were embedded in the same funding programme for innovative water reuse but differed in regard to technologies developed and fields of application. The following sections are both based on publicly available information obtained from the project websites and publications as well as from the interviews conducted. First, the project HighCon is presented (section 4.1), followed by HypoWave (4.2), MULTI-ReUse (4.3) and REMEMBER (4.4).

4.1 HIGHCON

The focus of the HighCon was the reuse of water and concentrates from industrial wastewater. The project was conducted between September 2016 and December 2019. Table 8 provides an overview of participants, interviewees and test plant locations.

Table 8: General Information HighCon

Participants (total number: 12)	**Interviewees**
Research institutions: 1. DVGW-Research centre at Engler-Bunte-Institute 2. Fraunhofer Institute for Solar Energy Systems (ISE) 3. DECHEMA Society for Chemical Technologies and Biotechnology 4. TU Berlin, Chair for Environmental Process Engineering Practice partners 1. Terrawater GmbH 2. DEUKUM GmbH 3. SolarSpring GmbH 4. WEHRLE Umwelt GmbH 5. MEWA Textil-Service AG & Co. Groß Kienitz OHG 6. DEK Deutsche Extrakt Kaffee GmbH 7. Clariante Produkte (Deutschland) GmbH 8. L'Oréal	1 Researcher (Coordinator) 1 Researcher 1 Practitioner **Locations** Berlin Wolfsburg Braunschweig Munich

One obstacle to reusing industrial wastewater are substances such as salt that are resolved within the water (Götz et al., 2019). The project HighCon aimed for the advancement of technologies to separate such substances from water to allows the reuse of both by applying a process generally known as Zero Liquid Discharge (ZLD). To do so, test plants at various locations from companies active in the textile, cosmetics, coffee and chemical sectors were built and laboratory work was conducted to analyse the functionality of the technologies put in place.

The project was initiated by two researchers working on wastewater reuse and further participants were included step by step. Hereby, many participants knew each other through previous collaborations. The following figure 9 visualises how the work was split up. Firstly, and to identify relevant industries, a technical, economic and ecological analysis was conducted. After further developing and adapting technologies such as membrane distillation, crystallisation or electrodialysis, the test plants were installed at various locations. The project was finalized with a market analysis and a life cycle assessment of the technologies applied.

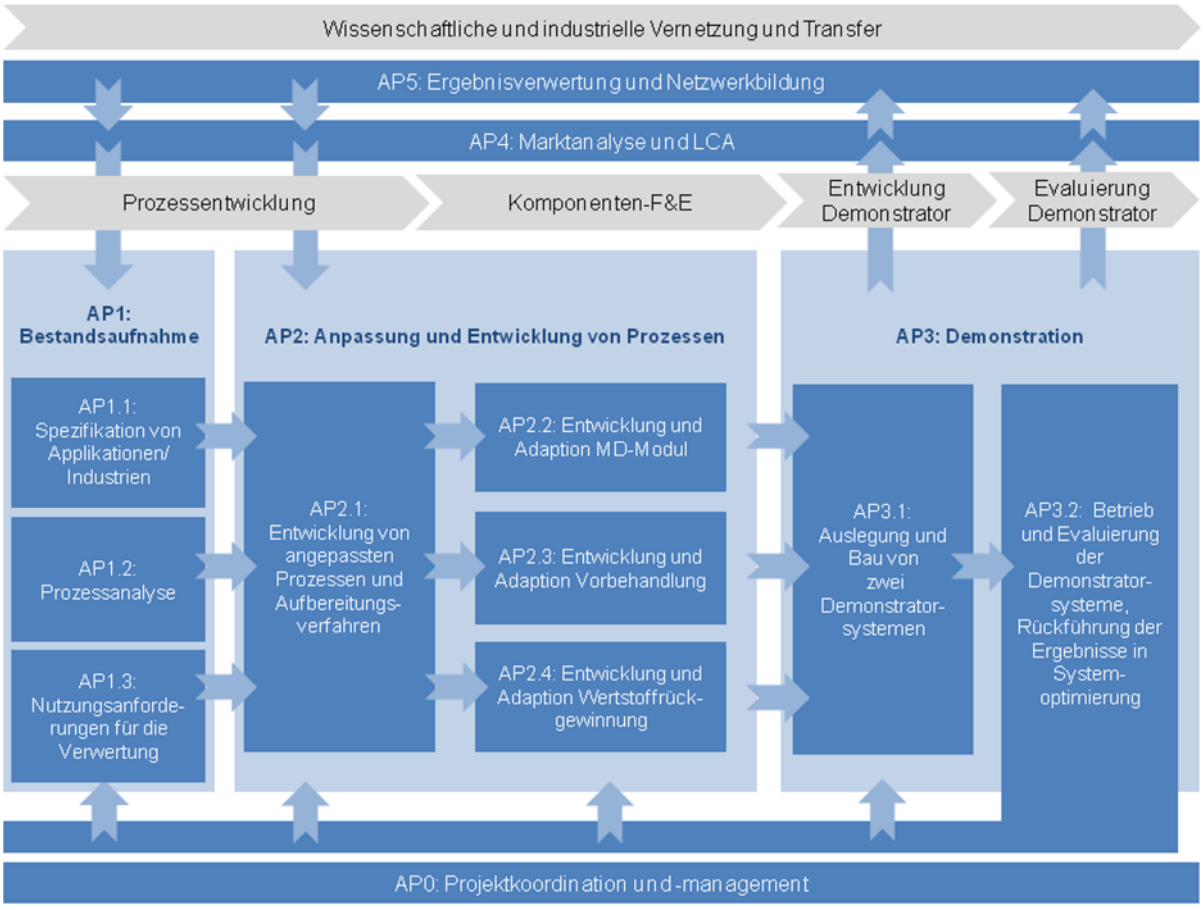

Figure 9: Process of HighCon

(derived from highcon.de, 27th August 2020)

4.2 HYPOWAVE

The focus of HypoWave was water reuse for plant breeding. The project was conducted from September 2016 until January 2020. Table 9 provides an overview of participants, interviewees and test plant locations.

Table 9: General Information HypoWave

Participants (total number: 13)	**Interviewees**
Research institutions 1. Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) 2. Institute for Social-Ecological Research (ISOE) 3. TU Braunschweig, Institute for Sanitary and Environmental Engineering 4. Julius Kühn-Institut (JKI), Federal Research Institute for Cultivated Plants 5. University of Hohenheim, Institute of Agricultural Sciences in the Tropics Practice partners 1. ACS-Umwelttechnik GmbH & Co. KG 2. Aquatectura – Studios for regenerative landscapes 3. Aquatune – Dr. Gebhardt & Co. GmbH 4. BIOTEC Naturverpackungen GmbH & Co. KG 5. Xylem Services GmbH 6. Wolfsburger Entwässerungsbetriebe [public wastewater treatment operator] 7. Abwasserverband Braunschweig [public wastewater treatment operator]	2 Researchers 1 Practitioner **Locations** Braunschweig Hessischer Ried Alentejo (Portugal)

The region around the city of Braunschweig faces a high-water demand in agriculture due to drained soils. To substitute the use of groundwater for irrigation purposes, wastewater reuse was also in history a key strategy: operators of municipal wastewater treatment plants and farmers look back at already 70 years

of collaboration for reusing wastewater for agricultural irrigation (Drewes et al., 2018). In the light of new residues in wastewater such as drugs, its reuse in agriculture needed to be re-evaluated to assess potentially harmful microbiological and chemical effects on the quality of the watered plants.

To do so, researchers and practitioners from the fields of agriculture and wastewater teamed up to develop holistic solutions reusing wastewater for plant breeding. Hereby, the technical, legal, economic and biological dimensions were investigated by numerous different actors.

To test the applicability of such a hydroponic system, a test plant was built up in a wastewater treatment plant near Braunschweig, northern Germany. To evaluate the transferability of the processes developed for the test plant, several case studies in different locations in Germany and Portugal were conducted. Here, each context was analysed and an adapted concept for implementing a hydroponic system was developed (see e.g. the publication on how to install hydroponic systems in the Alentejo, Portugal by Germer et al., 2020). A follow-up project with farmers in the region of the original test plant is in the planning. Figure 10 shows the basic steps of the process developed. Firstly, the wastewater goes through basic treatment. Then, the quality needed for plant breeding is secured e.g. with UV rays while keeping the needed nutrients in the water. The processed water is lastly brought into the hydroponic system to provide the plants with nutritious water.

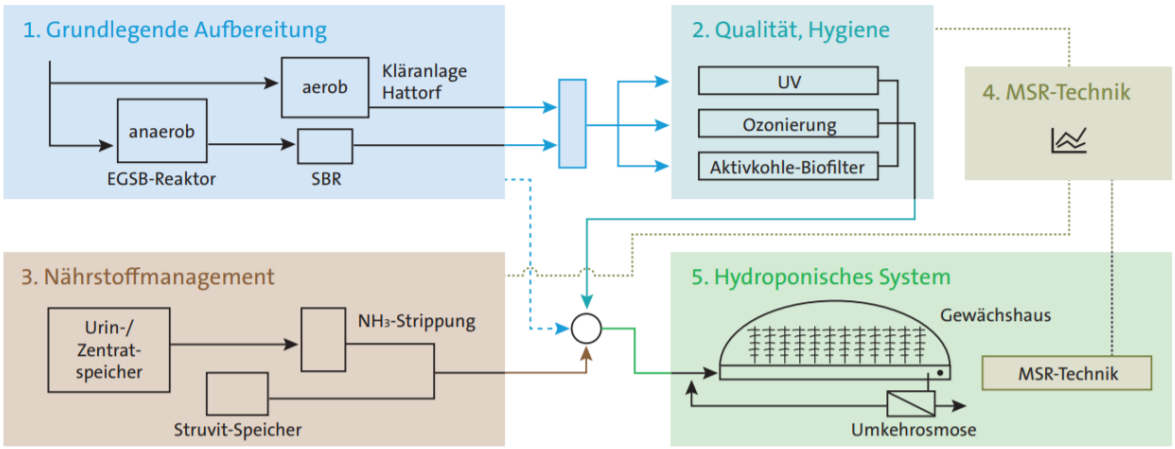

Figure 10: Process of HypoWave

(derived from hypowave.de, 27th August 2020)

4.3 MULTI-REUSE

The focus of MULTI-ReUse was the modular treatment for diverse water reuse applications. The project was conducted between September 2016 and January 2020. Table 10 provides an overview of participants, interviewees and test plant locations.

Table 10: General Information MULTI-ReUse

Participants (total number: 8)	**Interviewees**
Research institutions 1. University of Duisburg-Essen, Biofilm Centre 2. IWW Water Center GmbH 3. DECHEMA Society for Chemical Technologies and Biotechnology 4. Leibniz Centre for Agricultural Landscape Research (ZALF) 5. Institute for Social-Ecological Research (ISOE) Practice partners 1. inge GmbH 2. De.EnCon GmbH 3. Oldenburgisch-Ostfriesischer Wasserverband (OOWV) [public wastewater treatment plant operator]	1 Researcher (Coordinator) 1 Researcher 2 Practitioners
	Location
	Nordenham

Like many other regions in Europe, an area in north western Germany covering parts of East Friesland and the Oldenburg Land traditionally faces fresh-water scarcity. In addition, there is a high water demand due to numerous industrial plants or irrigation in agriculture (Rohn et al., 2018). These different water uses have different quality requirements. Hence, the project MULTI-ReUse was initiated to build up user-specific modules for wastewater reuse. By combining techniques such as ultrafiltration or reverse osmosis in a test plant in Nordenham, the different potentials for water provision for industry, agriculture or private households (e.g. for toilet flush) were assessed.

Several participants in the project knew each other beforehand. While most of the represented institutions had a technology-oriented focus, other dimensions such as legal, political and economic perspectives were also included. For example, the involved operator of the wastewater treatment plant where the test plant was installed, is a public company owned by the municipalities of the region. As some of the municipalities were convinced by the results, a follow-up project is planned. Figure 11 visualises the modular reuse process developed in MULTI-ReUse. The treatment plant (in the centre of the figure) applies different technologies such as reverse osmosis or disinfection to process urban wastewater depending on the different uses (visualizes in the corners of the figure).

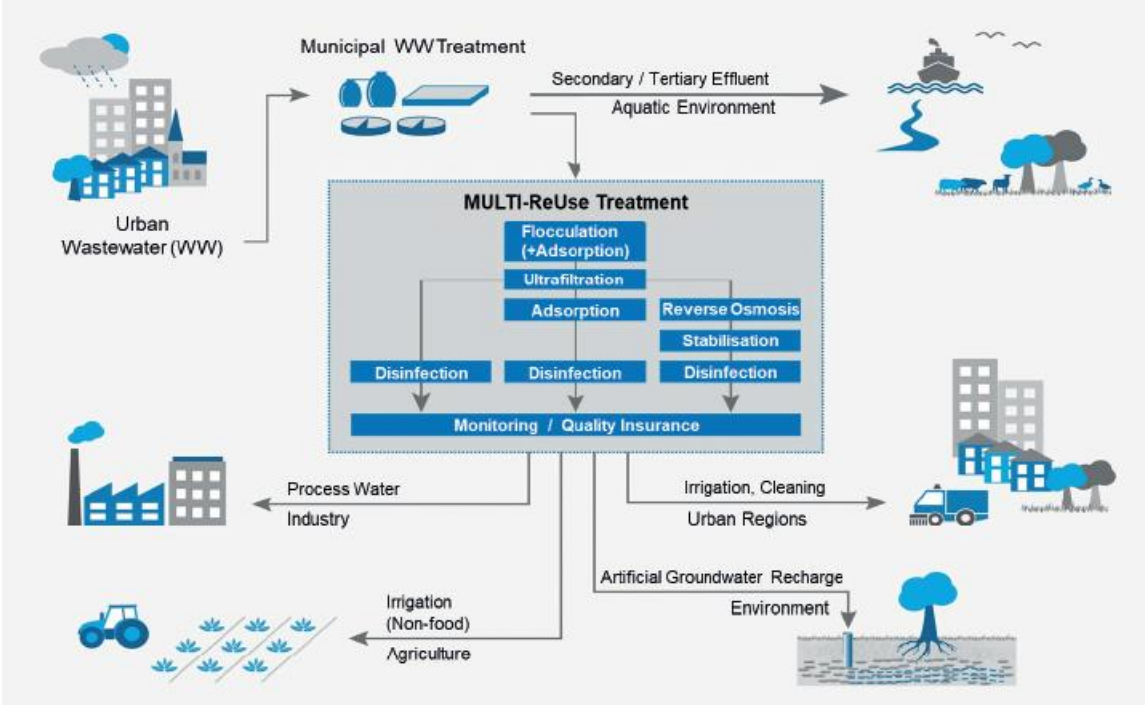

Figure 11: Process MULTI-ReUse

(derived from Rohn et al., 2018)

4.4 REMEMBER

The focus of REMEMBER was the advancement of membrane technologies for filtering wastewater. The project was conducted from September 2016 until January 2019. Table 11 provides an overview of participants, interviewees and test plant locations.

Table 11: General Information REMEMBER

Participants (total number: 6)	**Interviewees**
<u>Research institutions</u> 1. Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) 2. University of Bremen, Center for Environmental Research and Sustainable Technology (UFT) <u>Practice partners</u> 1. Plasmatreat GmbH, 2. nb technologies GmbH 3. Weser Umwelttechnik 4. MARTIN Membrane Systems AG	1 Researcher 1 Practitioner (Coordinator) **Location** Bremen

The effectiveness of membrane filters in processing water is often reduced by sediments – a problem called fouling or scaling (Lim & Bai, 2003). By applying a physical phenomenon named dielectrophoresis, the involved participants hoped to solve this issue. Dielectrophoresis is a process in which an electric field is formed with UV-laser rays to change the surface structure of e.g. a membrane filter. While this technology is already used in different fields, its application for wastewater filters is an innovative approach. Research institutes for material science and wastewater treatment started the project and worked together with plant manufacturers having experience with membrane filters. In a wastewater treatment plant near Bremen, northern Germany, a test plant was installed.[8]

[8] Unlike for the other three cases, there was no figure available on the project website of REMEMBER illustrating in detail the process developed.

5 FINDINGS FROM THE CASE STUDIES

This chapter presents the findings of the case studies and thereby answers sub-question b) *To what extent do experiences from joint knowledge production projects on wastewater reuse in Germany confirm the success factors identified in literature and how can these experiences help to further specify certain factors and their potential contribution to success?* The first section 5.1 explains the success degree of each project. In 5.2, the factors identified as relevant for the potential success of each project are presented. The comparison of the findings among the different cases in section 5.3 is followed by a revised success framework based on the findings (5.4).

5.1 EVALUATING SUCCESS

Based on the statements of the interviewed participants, the degree of success of each project was assessed. To this end, the participants' perceptions were translated into scorings for each of the success criteria (salience, credibility and legitimacy). As explained in section 3.1.2 of the methods chapter, "---" was assigned when all interviewees expressed that a certain criterion was not fulfilled at all, while "+++" was assigned when all saw a criterion as absolutely fulfilled. Firstly, the success evaluation of HighCon is presented (section 5.1.1), followed by HypoWave (5.1.2), MULTI-ReUse (5.1.3) and REMEMBER (5.1.4).

5.1.1 Success of HighCon

Table 12: Success of HighCon

Salience	+++
Credibility	+++
Legitimacy	++
Overall:	*Highly successful*

Based on the scorings assigned, HighCon presents the most successful project in terms of joint knowledge production as the knowledge system created was assessed with a very high degree of salience, credibility and legitimacy (see table 12).

All three interviewees expressed that they see the project as clearly successful. The coordinating researcher asked in the interview explicitly for the criteria indicating success and then affirmed that salience, credibility as well as legitimacy were fulfilled to a very high degree from his perspective. This was generally confirmed by the other two interviewees.

The practitioner working for a plant manufacturer stated that the results are highly relevant for their customers as they also see the issue of future water scarcity and understand substances such as salt as valuable resources. This interviewee further pointed at the great amount of learnings made throughout the project. Potentials and limitations of the technologies applied became visible and therefore allow subsequent steps. Thus, a maximum level of salience was assigned. The interviewees also saw a high credibility of results produced e.g. in the laboratory analysis about the composition of substances in the water before and after the filtration. Therefore, credibility was also assigned with "+++". The project was initiated by two researchers having already a well-defined idea about the objectives. Despite this pre-determined project frame, the two interviewees that were not part of the initiation phase expressed that they could bring in their perspectives. While especially one researcher mentioned a gap that existed between expectations from researchers and from practitioners in the project – e.g., more testing in the laboratory versus making the technology ready for the market – she was generally happy with how these potential points of conflict were solved. Thus, the project's legitimacy was assessed as high but not absolutely fulfilled.

5.1.2 Success of HypoWave

Table 13: Success of HypoWave

Salience	++
Credibility	++
Legitimacy	++
Overall:	*Very successful*

HypoWave was evaluated with the second highest scoring for salience, credibility and legitimacy. All three interviewees expressed their satisfaction with the process. However, several statements about minor issues led to a scoring of "++" instead of "+++" for each criterion (see table 13).

Confirming salience, the interviewed practitioner pointed at the important implications the results of HypoWave have for the future application of existing wastewater irrigation systems in regard to e.g. drug residues. With this statement, she also underlined the credibility of the results for her work. This was confirmed by one researcher who made an important discovery for her work by finding lower concentrations of certain substances in the plant products irrigated with treated wastewater as initially expected. Also, the second interviewed researcher perceived the knowledge produced as being highly salient and credible due to the various case studies conducted as they allow a certain degree of generalisation and transferability of the findings from the project. Furthermore, the high legitimacy of the process can be best underlined with a quote from one researcher who said: "no project partner was falling behind" (interview 5)[9]. The expressed fear of "too many cooks spoil the broth" (interview 6) given the high number of participants was not confirmed. However, the practitioner mentioned that she did not yet receive all the results that are valuable for her work and related this to the many objectives and processes within HypoWave. This statement slightly lowered the score for legitimacy as well as for salience and credibility as the project appeared too overloaded to make all results relevant and applicable for all participants.

[9] Quotations from the interviews are referenced with the interview number assigned in the list of all interviews conducted to be found in annex I.

5.1.3 Success of MULTI-ReUse

Table 14: Success of MULTI-ReUse

Salience	++
Credibility	++
Legitimacy	+
Overall:	*Successful*

The project MULTI-ReUse can be evaluated as overall successful based on the statements of the interviewees (see table 14). While three interviewees (two of them being from the same organization) agreed on a very high degree of salience, credibility and legitimacy of the results, one interviewee expressed a different understanding of the project's success which led to lower scores for each criterion.

For the practitioners and one researcher, the results from MULTI-ReUse are highly relevant and applicable in their daily work. For example, the monitoring tool developed for the modular processing of the wastewater can be also used for future work in the research institute of one interviewee. The practitioners emphasised that the process developed included all the relevant aspects from their perspective ranging from technical to political questions and thereby ensured a high applicability of the process. This applicability was underlined by a follow-up project to be realised at the location of the test plant. Hence, MULTI-ReUse was named by one interviewee a "flagship project" (interview 7) due to the functionality of the process and the public acceptance it received. Furthermore, assessment tools including a cost-benefit analysis were developed which was suggested as facilitating the upscaling of the technology. These statements indicated a high degree of salience and legitimacy. While these interviewees also felt that the process was very inclusive, one interviewed researcher clearly expressed discontent. He mentioned that he had to "fight" (interview 10) for his concerns to be included in the process. Congruent with this statement one other researcher with a more technologically focused perspective expressed that she "did not always get his perspective" (interview 7). This situation lowered the scoring for legitimacy to a "+". Due to the lack of inclusion of his more social-ecological driven perspective, the interviewee also felt that the results are not as relevant and applicable for him

as they could have been. However, due to several publications developed, he also saw a certain degree of salience and credibility. This perspective merged with the very positive statements of all other interviewees led to a scoring for salience and credibility of "++" for each.

5.1.4 Success of REMEMBER

Table 15: Success of REMEMBER

Salience	+
Credibility	++
Legitimacy	++
Overall:	*Successful*

The project REMEMBER was also evaluated as being overall successful (see table 15). The two interviewees mentioned that the results are generally relevant and useful for them as the learnings about applying dielectrophoresis is valuable for their respective professional fields. For example, they could show that this physical phenomenon increases the efficiency of membranes filtering water. Furthermore, it became apparent that this technology has a high energy need – an important though not desired result. Therefore, credibility was assigned a high score. However, the interviewed researcher emphasised that the project results could be significantly more relevant if the full potential of the project would have been explored by making "the last steps" (interview 12) as in bringing the different results together to improve the overall process. While salience consequently was scored with only "+", the legitimacy was assessed as very high. Both interviewed participants emphasised that a very inclusive atmosphere was created throughout the project and everybody willing to contribute could do so.

5.2 EVALUATING SUCCESS FACTORS

On the following pages, the relevant success factors for each project are discussed. As explained in 3.1.2, a factor was rated as relevant when it could be identified in interview statements as having contributed to potential success of the respective project. The degree of relevance was indicated from "0" (not mentioned explicitly

or mentioned as not relevant for success) to "++" (mentioned as highly relevant for potential success by all interviewees).

5.2.1 Success Factors in HighCon

Based on the interviews with participants from HighCon, fourteen factors could be detected as having had a positive impact on the overall success of the project. Table 16 illustrates the relevance of each factor.

Table 16: Success Factors in HighCon

Success Factors	Scoring
Boundary concepts	
Acknowledgement of differences	++
Balanced problem ownership	0
Clear role distribution	0
Joint goal definition	++
Joint problem definition	++
Boundary objects	
Material boundary objects	++
Facilitators	++
Reward products for all	0
Boundary settings	
Accountability	++
Balanced power relations	0
Broad actor coalition	++
Continuous participation	+
Evaluation procedures	0

Flexibility	+
Funding	0
Informal exchange	+
Productive conflict	0
Project initiation by society	0
Recursiveness	0
Trustful collaboration	++
Factors mentioned that were not included in the initial framework[10]	
Anticipatory project planning	++
Bilateral exchange	++
Previous collaboration	++

The *acknowledgement of differences* among the numerous perspectives from various actors was expressed by two interviewees as both present and very important to develop a functioning project. Realising that especially the partners from practice and the more research-oriented ones differed in their expectations on where to focus on was seen as a necessary step to allow the *joint goal definition* and *joint problem definition*. The presence of these two factors was also nurtured by writing together the application for the funding scheme (within the boundaries of the original idea from the initiators) and also the results were written down in joint papers. Furthermore, the discussions in the project meetings were directed toward the intersection points of the different working packages.

As a materialisation of intersection points served the test plant. This *material boundary object* required and allowed all project partners to bring together their different results derived from lab work or the development of technical components. Also, the coordinator's role as a *facilitator* that mediates conflicts and

[10] As explained in section 3.1.3 of the methods chapter, these factors were inductively derived from interview statements while the other factors were deductively derived from the initial framework.

takes important decisions was mentioned as key for success. He provided an overall framework for the project, assigned tasks and required results. Such a clear lead narrowed down the creativity of the individual actors. However, it was perceived by two interviewees as very positive, that "he had courage" (interview 3) to give a clear lead.

Regarding the boundary settings, a high level of *accountability* as in the willingness among the participants to invest more than formally requested was decisive for ensuring a successful path. To integrate all perspectives needed to develop the technology, a *broad actor coalition* was built. However, the initiating coordinator picked consciously the partners to be involved in order to prevent a fragmentation of concerns and objectives throughout the project. Also, one potential partner dropped out voluntarily as he missed the scientific depth in regard to certain aspects. Thus, not every potential partner was included at any cost. Rather, in the beginning a red line and a certain common ground was tried to be ensured. The involvement of the end-users of the substance-separation plant was highlighted as very key to guarantee the applicability of the results. *Continuous participation* and *flexibility* helped to adapt to changing circumstances while maintaining the core team. A certain level of *informal exchange* and a high level of *trustful collaboration* contributed to a smooth communication throughout the process.

Besides these factors derived from the initial framework, several points could additionally be identified as highly relevant. The coordinator expressed the importance of *anticipatory project planning*: "Are you at the right time at the right place or did you do a specific research ten years to early?" (interview 1). The other two interviewees expressed that *bilateral exchange* was as important as the group conversations to be able to have an effective exchange about particular intersection points. And lastly, many of the partners knew each other from *previous collaborations* which had a positive impact on the level of trust and on acknowledging differences in perspectives.

5.2.2 Success Factors in HypoWave

Based on the interviews with participants from HypoWave, fifteen factors could be detected as having had a positive impact on the overall success of the project. Table 17 illustrates the relevance of each factor.

Table 17: Success Factors in HypoWave

Success Factors	Scores
Boundary concepts	
Acknowledgement of differences	++
Balanced problem ownership	0
Clear role distribution	0
Joint goal definition	++
Joint problem definition	++
Boundary objects	
Material boundary objects	++
Facilitators	++
Reward products for all	0
Boundary settings	
Accountability	++
Balanced power relations	0
Broad actor coalition	++
Continuous participation	+
Evaluation procedures	++
Flexibility	+
Funding	0
Informal exchange	+

Productive conflict	0
Project initiation by society	0
Recursiveness	0
Trustful collaboration	+
Factors mentioned that were not included in the initial framework	
Anticipatory project planning	++
Bilateral exchange	++
Previous collaboration	++

As the project aimed for a holistic for researching wastewater reuse for farming, many perspectives were included. However, the participants were already in the beginning aware of the huge number of "cooks" (interview 6) that came together. Hence, there was an *acknowledgement of differences* in perspectives, which allowed to constructively bring them together while accepting that not everybody needs to understand everything in detail. With this approach in mind, various partners met several times before writing the project application and reached a high degree of harmonisation of expectations about the project. This fruitful *joint problem definition* and *joint goal definition* was kept throughout the process and several publications and factsheets were produced together by scientists and practitioners. The case studies conducted in other regions than the original test region helped to identify different problem constellations and allowed to integrate a proper social analysis of the respective contexts.

On a more concrete level, the test plant in the test region served as a *material boundary object* that required and allowed the development of applicable processes. Also, the work of the coordinators was perceived as very positive. They fulfilled their role as *facilitators* by being knowledgeable in the different topics of the project – mainly wastewater and agriculture – as well as skilful when it came to methods on how to realise inter- and transdisciplinary work.

A high level of *accountability* could be detected. Many participants had an interest in the project beyond realising the test plant. One interviewee mentioned that all participants showed a similar level of motivation, implying that very dispersed levels of engagement could have been counterproductive. While it was mentioned as very positive to have such a *broad actor coalition* in order to evaluate the various dimensions of the problem at hand, the interviewed practitioner emphasised that she sometimes felt overwhelmed. However, formative *evaluation procedures* allowed the adjustment to the needs and concerns of individual participants. With EvaluNet – an evaluation tool specifically developed for transdisciplinary projects[11] – the comments and critiques of all participants were visualised in radar pictures and discussed at the project meeting. Also, the *continuous participation* of most partners and *flexibility* in the process were perceived as positive. Besides these institutionalised forms of communication, a basic level of *informal exchange* and *trustful collaboration* was reached through project meetings at the various locations of the different partners including dinners or an excursion with young researchers within the project.

Furthermore, the *bilateral exchange* among individual partners and *previous collaborations* were mentioned as positive for a productive process. Lastly, the interviewees underlined the relevance of *anticipatory project planning*, as in foreseeing and reacting to potential issues with wastewater reuse for plant breeding due to e.g. residues.

5.2.3 Success Factors in MULTI-ReUse

Based on the interviews with participants from MULTI-ReUse, twelve factors could be detected as having had a positive impact on the overall success of the project. Table 18 illustrates the relevance of each factor.

[11] The following website explains in detail this evaluation tool: https://www.ioew.de/projekt/evaluationsnetzwerk_fuer_transdisziplinaere_forschung_evalunet

Table 18: Success Factors in MULTI-ReUse

Success Factors	Scoring
Boundary concepts	
Acknowledgement of differences	+
Balanced problem ownership	0
Clear role distribution	++
Joint goal definition	+
Joint problem definition	+
Boundary objects	
Material boundary objects	+
Facilitators	+
Reward products for all	0
Boundary settings	
Accountability	+
Balanced power relations	0
Broad actor coalition	++
Continuous participation	+
Evaluation procedures	0
Flexibility	++
Funding	0
Informal exchange	+
Productive conflict	0
Project initiation by society	0
Recursiveness	0

Trustful collaboration	0
Factors mentioned that were not included in the initial framework	
Anticipatory project planning	0
Bilateral exchange	0
Previous collaboration	++

While all interviewees clearly expressed an existing *acknowledgement of differences* in the project, there was not a consensus about the relevance of each perspective for the project. However, this allowed a *clear role distribution*, as in having a clear differentiation of project goals and partner goals. As described in 5.1.3, one interviewee felt that his perspectives and concerns were rather treated as separate from the overall project and thus not included into a *joint goal definition* and *joint problem definition*. This was also due to his involuntary absence in the application phase. A flow diagram, that could have facilitated the joint goal and problem definition, existed but was not applied and assessed consistently throughout the project.

Assessing the relevance for success of the *material boundary object* in form of a test plant as well as the coordinators acting as *facilitators* was hard due to the conflicting statements. While one interviewee expressed some doubts in this regard, others emphasised the high relevance for success that the test plant and the coordinators had. They especially highlighted the clear but adaptive lead given by the coordination as well as their profound expertise on the topic. Thus, both factors were evaluated as slightly relevant.

Several factors within the setting of the project were also mentioned as key for success. A certain level of *accountability* was present as all participants wanted to make the best out of the project. The *broad actor coalition* including research institutions, plant manufacturers and actors with political, legal and societal expertise was perceived as highly necessary for success by all participants. Here, the applicability for end-users, such as public or private wastewater treatment plant operators, was ensured via the inclusion of the public water union as a project participant. Part of the consortium was also a partner focusing on public relations

to gain attention for the project. Moreover, *continuous participation* was perceived as important. The adaptive project lead mentioned above also facilitated a high level of *flexibility* throughout the project. Furthermore, *informal exchange* at e.g. project meetings, was mentioned by one interviewee as important to create a good atmosphere.

Additionally, *previous collaboration* between certain actors contributed to a good communication.

5.2.4 Success Factors in REMEMBER

Based on the interviews with participants from REMEMBER, ten factors could be detected as having had a positive impact on the overall success of the project. Table 19 illustrates the relevance of each factor.

Table 19: Success Factors in REMEMBER

Success Factors	Scoring
Boundary concepts	
Acknowledgement of differences	0
Balanced problem ownership	0
Clear role distribution	0
Joint goal definition	+
Joint problem definition	+
Boundary objects	
Material boundary objects	0
Facilitators	+
Reward products for all	0
Boundary settings	
Accountability	0

Balanced power relations	0
Broad actor coalition	+
Continuous participation	+
Evaluation procedures	0
Flexibility	+
Funding	0
Informal exchange	++
Productive conflict	0
Project initiation by society	0
Recursiveness	0
Trustful collaboration	++
Factors mentioned that were not included in the initial framework	
Anticipatory project planning	0
Bilateral exchange	++
Previous collaboration	++

While a certain level of *joint problem definition* and *joint goal definition* was present, it was mentioned by one interviewee that more thorough discussions about which perspective each actor has and how to harmonise them would have been beneficial for the project's success.

Both the official coordinator as well as one participant supporting him, served as *facilitators*. Especially the informal lead of the latter was perceived in both interviews as important to keep the project on track. However, this situation also complicated a smooth information flow as e.g. the funding agency always communicated directly with the official coordinator.

A relatively *broad actor coalition* could be reached, however, the interviewees mentioned that one or two additional partners with expertise e.g. in energy

efficiency would have been valuable. Also, certain levels of *continuous participation* and *flexibility* were given. While all the factors mentioned until now were only slightly relevant for evaluating the overall project as a success, *informal exchange* and *trustful collaboration* could be deduced as highly relevant from the interview statements. In both interviews, the good atmosphere in the project, as well as the companionable and respectful communication were explicitly mentioned as having made the collaboration very fruitful and pleasant. For example, organizing project meetings at the various partner locations was suggested as a great opportunity to get to know each other better.

In line with this, good *bilateral exchange* and *previous collaboration* were mentioned as highly relevant for the success.

5.3 CASE COMPARISON

By comparing the results throughout the projects, several patterns among success criteria (section 5.3.1) and success factors could be identified (section 5.3.2). In section 5.3.3, the assumptions made about links between particular success criteria and factors (see section 2.2.3) are evaluated based on the empirical findings of the case studies.

5.3.1 Success

Table 20 gives an overview of the success scorings of all four cases. Combined with the qualitative insights presented in section 5.1, several observations can be made.

Table 20: Comparison of Success among Cases

	HighCon	**HypoWave**	**MULTI-ReUse**	**REMEMBER**
Salience	+++	++	++	+
Credibility	+++	++	++	++
Legitimacy	++	++	+	++
Overall:	*Highly successful*	*Very successful*	*Successful*	*Successful*

a) All projects were perceived by all interviewees as generally successful. HighCon stands out with only missing one "+" before reaching the best

possible score. In each of the three cases HighCon, HypoWave and MULTI-ReUse, salience and credibility received the same scoring and a higher scoring than legitimacy.

b) Throughout the projects, most interviewees confirmed the question of whether the project was successful by firstly pointing at the salience (thus, relevance) of the results produced. Regardless of whether the results were desired or not, both practitioners as well as researchers expressed that they were provided with important insights regarding the functionality of a certain process. This indicates a privileged role of salience when evaluating success.

c) Often, salience of the results was explained together with credibility as in being applicable in the different working contexts of the various participants. Together with the similar scoring of these two criteria, this points to a high overlap between salience and credibility.

d) When evaluating salience and credibility, there were notable differences among interviewed researchers and practitioners. Researchers participating in HighCon, HypoWave, MULTI-ReUse or REMEMBER often mentioned testing results and the development of testing or monitoring tools as relevant results. In contrast, practitioners throughout the projects (except for REMEMBER) rather pointed at follow-up projects or the applicability under real circumstances. However, while HighCon, HypoWave and MULTI-ReUse sought for immediate commercialisation of the processes developed, REMEMBER focused rather on fundamental research to see whether the technological process generally works. Consequently, the salience and credibility of the results in REMEMBER were also assessed by practitioners from a plant manufacturing company by pointing at important insights for research and development and not by pointing at its direct applicability.

e) In each of the three cases HighCon, HypoWave and MULTI-ReUse, salience and credibility scored higher than legitimacy. In MULTI-ReUse, a high scoring of salience and credibility was given despite the only slightly positive scoring for legitimacy. The interviewed participant who felt excluded throughout the process (which lead to a rather low overall level of legitimacy assigned) expressed that despite this, it was possible to "cannibalise" (interview 4) the project with various publications. This in turn made the project results still relevant and applicable (and thus ensured a high overall level of salience and credibility). This indicates that a high level of salience and credibility can be reached also when legitimacy is low.

f) In HypoWave and HighCon in which many different stakeholders participated, legitimacy was not assessed as whether an individual participant was always aware of what was going on and could always share its opinion on every decision. Rather, it was appreciated when their concerns were addressed in key steps of the process so that the results were also relevant and applicable for them. This points to a certain positive correlation between the three criteria throughout the projects.

5.3.2 Success Factors

Table 21 brings together the evaluations from the different cases about which factors were relevant for the potential success. In the table, the quantitative scorings are briefly explained. The following pages then elaborate in detail on each factor.

Table 21: Comparison of Success Factors among Cases

Success Factors	**HighCon** Salience: +++ Credibility: +++ Legitimacy: ++	**HypoWave** Salience: ++ Credibility: ++ Legitimacy: ++	**MULTI-ReUse** Salience: ++ Credibility: ++ Legitimacy: +	**REMEMBER** Salience: + Credibility: ++ Legitimacy: ++
Boundary Concepts				
Acknowledge-ment of differences	++ Acknowledged and appreciated	++ Acknowledged and appreciated	+ Acknowledged but not all appreciated	0 Unclear
Balanced problem ownership	Not explicitly mentioned but overlaps with accountability as well as joint problem definition and joint goal definition			
Clear role distribution	0 Not explicitly mentioned but overlaps with joint problem definition and joint goal definition	0 Not explicitly mentioned but overlaps with joint problem definition and joint goal definition	++ Clear differentiation between project and partner goals	0 Not explicitly mentioned but overlaps with joint problem definition and joint goal definition
Joint goal definition	++ Explicit deliberation huge overlap with joint problem definition	++ Explicit deliberation huge overlap with joint problem definition	+ Explicit deliberation without one participant huge overlap with joint problem definition	+ No explicit deliberation huge overlap with joint problem definition
Joint problem definition	++ Explicit deliberation huge overlap with joint goal definition	++ Explicit deliberation huge overlap with joint goal definition	+ Explicit deliberation without one participant huge overlap with joint goal definition	+ No explicit deliberation huge overlap with joint goal definition

Boundary objects				
Material boundary objects	++ Test plant	++ Test plant	+ Test plant but discontent	0 Test plant but not mentioned as relevant
Facilitators	++ Clear guidance	++ Inclusive	+ Clear guidance but discontent	+ Mix of formal and informal
Reward products for all	Not mentioned but overlap with the criteria salience and credibility.			
Boundary settings				
Accountability	++ Investment beyond the formal	++ Similar degree of accountability	+ Lack of investment by one participant	0 Not mentioned as relevant but lack of investment by one participant
Balanced power relations	Not explicitly mentioned, but project initiation phase might be decisive in regard to whose concerns are included more or less.			
Broad actor coalition	++ Various actors but focus on technical aspects	++ Various actors but focus on technical aspects	++ Various actors but focus on technical aspects	+ Narrowed down to several actors
Continuous participation	+ Given Overlaps with accountability	+ Given but drop-out of one participant Overlaps with accountability	+ Given Overlaps with accountability	+ Given Overlaps with accountability

Evaluation procedures	0 Not mentioned	++ Formative evaluation	0 Not mentioned as relevant but one participant noted that it missed it	0 Not explicitly mentioned
Flexibility	+ Necessary to adapt to changing circumstances	+ Necessary to adapt to changing circumstances	++ Necessary to adapt to changing circumstances Positive attribute of coordinator	+ Necessary to adapt to changing circumstances
Funding	Not mentioned as relevant but imbalance in funding for researchers and companies was discussed	Not mentioned as relevant but one partner had to drop-out due to ending funding	Not explicitly mentioned	Not explicitly mentioned
Informal exchange	+ E.g. at project meetings	+ E.g. at project meetings	+ E.g. at project meetings	++ Positive atmosphere and good communication
Productive conflict	0 Not explicitly mentioned	0 Not explicitly mentioned	0 Not mentioned as relevant but noted that constructive criticism was mentioned in relation with evaluation procedures	0 Not explicitly mentioned
Project initiation by society	0 All projects were initiated by researchers solely or in collaboration with practitioners. However, the researchers were sensitive to the societal and not only scientific aspects of the problem.			

Recursiveness	0 Not mentioned as relevant but noted that funding structure makes repetition of steps hard.	0 Not mentioned as relevant but noted that funding structure makes repetition of steps hard.	0 Not explicitly mentioned	0 Not explicitly mentioned
Trustful collaboration	++ Overlaps with informal exchange, bilateral exchange and accountability	+ Overlaps with informal exchange, bilateral exchange and accountability	0 Not explicitly mentioned	++ Overlaps with informal exchange, bilateral exchange and accountability
Factors mentioned that were not included in the initial framework				
Anticipatory project planning	++ Right time, right place	++ Very timely issue	0 Not mentioned as relevant	0 Not mentioned as relevant
Bilateral exchange	++ Direct communication beyond project meetings Overlaps with trustful collaboration and informal exchange	++ Direct communication beyond project meetings Overlaps with trustful collaboration and informal exchange	0 Not explicitly mentioned	++ Direct communication beyond project meetings Overlaps with trustful collaboration and informal exchange
Previous collaboration	++ Facilitating presence of acknowledge-ment of differences, trustful collaboration, or informal exchange	++ Facilitating presence of acknowledge-ment of differences, trustful collaboration, or informal exchange	++ Facilitating presence of acknowledge-ment of differences, trustful collaboration, or informal exchange	++ Facilitating presence of acknowledge-ment of differences, trustful collaboration, or informal exchange

Two key quantitative observations can be made based on the table:

a) The factors *acknowledgement of differences*, *joint problem definition*, *joint goal definition, facilitators*, *material boundary objects*, *facilitators*, *accountability*, *broad actor coalition*, *continuous participation*, *flexibility*, *informal exchange*, *trustful collaboration*, *bilateral exchange* and *previous collaboration* were all mentioned in at least three out of four cases as having been relevant for success.

b) For the projects HighCon and HypoWave, that were evaluated as "highly successful" respectively "very successful", fourteen respectively fifteen factors could be identified as relevant (including the additionally mentioned ones). In contrast, for the two projects identified as "successful", MULTI-ReUse and REMEMBER, twelve respectively ten factors could be identified. Thus, by trend, the more successful a project, the more factors could be identified as relevant for success.

In the following, each of the factor is discussed in detailed based on the comparison of the cases.

Boundary concepts

→ Non-physical terms, definitions, visualisations or the alike that facilitate the communication within a process of JKP.[12]

Acknowledgement of differences

→ Explicit recognition by all participants within a particular JKP process that the different stakeholders may have a different understanding of the problem, the solution and differing reasons to be concerned.

The statements made by one interviewee that participated in both projects HypoWave and MULTI-ReUse points at a difference between

[12] The definitions of the various success factors (indicated with "→") were originally developed in section 2.2.2 and are repeated here to contextualize the empirical findings.

acknowledging and appreciating the different perspectives. In MULTI-ReUse, both the participant himself as well as other interviewees acknowledged that his social-ecological approach stood in contrast to the more technology-oriented perspectives of the rest. While the differences were clear, the participant felt that he had to fight for his perspective also being included and accepted as legitimate and important for the project. In HypoWave, he felt that his perspective was both acknowledged and valued which in turn contributed to a high perception of legitimacy by this actor.

Balanced problem ownership

→ All participants can bring in their specific concerns and nobody is dominating the process.

This factor was hard to detect during the interviews. However, *accountability* as well as *joint problem definition* and *joint goal definition* seemed to also touch the issue of *balanced problem ownership*.

Clear role distribution

→ Every participant is aware of what his or her own task is to contribute to the project goals.

In most projects, the presence and relevance of a *clear role distribution* went hand in hand with the *joint definitions of problems and goals*. Both in HighCon and in MULTI-ReUse interviewees pointed to the difficulty of bringing results together in the end of the projects when the different working foci of the participants were kept separated for too long.

Joint goal definition[13]

→ The participants communicate about and agree on an objective to be reached within the JKP process.

Statements about this factor could often not be separated from statements about *joint problem definition*. In the projects HighCon, HypoWave and

[13] The comparison in regard to joint goal definition is the exact same as for joint problem definition due to the inability to differentiate between these two factors in interview statements.

MULTI-ReUse, explicit discussions about the problems and goals of the project took place in the very beginning. Hereby, the project initiator in HighCon pre-defined already the general framing of the project whereas in HypoWave, finding problem and goal definitions appeared to be more of an inclusive process. This was also the case for MULTI-ReUse; however, one interviewee could not participate in the initiation phase and therefore the joint definitions lacked his perspective. One interviewee from REMEMBER explicitly stated that he missed the development of a joint understanding of problems and goals in the very beginning: "One time for all bringing everything on paper […] where do we start and what do we aim for […] like a common sense [so that] all act on the same knowledge base" (interview 12).

Joint problem definition[14]

→ In an interplay with the joint goal definition, the participants communicate about what they see as the problem to be solved and formulate a problem definition that respects all the different concerns.

Statements about this factor could often not be separated from statements about *joint goal definition*. In the projects HighCon, HypoWave and MULTI-ReUse, explicit discussions about the problems and goals of the project took place in the very beginning. Hereby, the project initiator in HighCon pre-defined already the general framing of the project whereas in HypoWave, finding problem and goal definitions appeared to be more of an inclusive process. This was also the case for MULTI-ReUse; however, one interviewee could not participate in the initiation phase and therefore the joint definitions lacked his perspective. One interviewee from REMEMBER explicitly stated that it missed the development of a joint understanding of problems and goals in the very beginning: "One time for all bringing everything on paper […] where do we start and what do we aim for […] like a common sense [so that] all act on the same knowledge base" (interview 12).

[14] The comparison in regard to joint problem definition is the exact same as for joint goal definition due to the inability to differentiate between these two factors in interview statements.

Boundary objects

→ Material objects or human subjects that allow acting within a JKP process by offering points of contact for the different contributions of different actors.

Material boundary objects

→ Material objects or devices that are graspable and foster the different participants to contribute components that make the overall object complete or working.

All four projects used one or several test plants to test assess technical fit of the particular components. However, due to external conditions such as the water quality in a particular wastewater treatment plant, the results were often rather context specific. Also, interviewees from HighCon and REMEMBER mentioned that the development of certain technical components can take more time than available in particular project. In HighCon and HypoWave, a cloud storage system was used to provide immediate access for all to e.g. test results.

Facilitators

→ Participants within the project that mediate between different perspectives, solve conflicts, coordinate tasks or make decisions in critical moments. These facilitators can be either officially assigned for such role or assume this function more informally.

In all four projects, the role of the coordinators was perceived as key for success. While HighCon and MULTI-ReUse stand out with a rather strong guidance by the project coordinators, in HypoWave the coordinators used formative evaluation procedures to include feedback by all participants. Both approaches were perceived as positive by the interviewees of the respective projects. In REMEMBER, part of the success was explained with the unofficial co-coordination assumed by one participant to support the assigned coordinator. However, this also led to some delays in information flow with e.g. the funding agency as they always contacted the official coordinator. The various approaches on how to fulfil the coordination role in

a successful way is also emphasised by the fact that most of the interviewed coordinators themselves as well as some other interviewees pointed to the need for flexible coordination to adapt to internal group dynamics and to external influences.

Reward products for all

→ Concrete material or immaterial things that translate the results in products that are perceived as useful in the respective working contexts of different participants.

This factor was hard to detect throughout the projects. It became apparent that there is an overlap of this factor with the criteria *salience* and *credibility*. When asked about the success of their projects, interviewees often pointed to the usable results from the projects such as monitoring tools or technologies.

Boundary settings

→ Settings, including the number of participants or evaluation procedures, that allow a fruitful context in which the boundary concepts and objects can be developed.

Accountability

→ Basic level of responsibility for the project that is shared among all participants.

The investment of more than formally requested by all participants was mentioned as relevant for success especially in interviews on HighCon. One participant of HypoWave emphasised positively the balanced motivation of different participants indicating that a high asymmetry in willingness and capacity to contribute can lead to conflicts. REMEMBER and HypoWave both faced one participant that showed a low level of accountability. However, this could be absorbed by a joint effort of the other participants.

Balanced power relations

→ Given that different participants have different levels of resources, authority or leverage in different contexts, nobody should have a disproportionately high influence within a JKP process.

This factor was hard to detect. However, the project initiation phases of HighCon and MULTI-ReUse – in which not all of the latter participants were involved in all decisions – showed that this part of the process can facilitate and limit possible options for actions later on and thus pre-determining power relations within the projects.

Broad actor coalition

→ An actor coalition that brings together all relevant stakeholders while not exceeding a manageable number of participants.

While both the website of the overall funding programme as well as most of the interviewees emphasised the fact that their respective projects brought together a very broad range of perspectives, it became apparent that most of the participants came from a rather technical field. This situation was best described in a statement from one interviewee who said: "this project was for sure in a way transdisciplinary but in the end, we were all engineers who contributed" (interview 11). However, most projects conducted also economic analyses, evaluating the cost-benefit-performance of the technologies developed and/or conducting a market analysis to test the applicability. In MULTI-ReUse and HypoWave, one actor with a clear social-ecological profile was included. In MULTI-ReUse, HypoWave and HighCon, many interviewees highlighted the importance of having end-users of the technologies directly or indirectly involved from the beginning to ensure applicability and acceptance. It is also noteworthy, that in most projects, the coalition of actors was influenced by *previous collaborations*.

Continuous participation

→ All relevant stakeholders are involved and present throughout the JKP process.

Continuous participation – at least of the core team – was mentioned as key for success in all projects. The drop-out of one participant in HypoWave caused some trouble as tasks had to be reassigned. However, one interviewee of HypoWave pointed also to the benefit of allowing some changes in the actor coalition as this can provide, for example, the necessary expertise that was not anticipated from the beginning.

Evaluation procedures

→ Formative evaluation throughout the JKP process in order to identify and address unexpected or undesired developments.

For HypoWave, two interviewees explicitly mentioned the institutionalised formative evaluation of the process as very important to ensure the inclusion of all stakeholders and their current concerns throughout the project. This was missed in MULTI-ReUse by the interviewee who participated in both projects and taken as an explanation of why the process was sometimes rather multi- than interdisciplinary. However, it was hard to detect in the interviews whether informal evaluation procedures were in place. For example, the coordinator from MULTI-ReUse expressed that she was observing the dynamics within the project and reacted, when needed. This points to the existence of informal evaluation procedures.

Flexibility

→ Flexibility in time, content and methods throughout the JKP process to adjust to unexpected or undesired developments.

Flexibility or adaptiveness were mentioned as key factors in all projects for a variety of reasons: appropriate reactions to external influences (e.g. hot temperature around the test plant affecting the water quality) or internal dynamics (e.g. one participant lacks accountability). Especially in MULTI-ReUse, such adaptiveness in managing the project was mentioned by the interviewees as a very positive attribute of the coordinator.

Funding

→ Secured funding throughout the process.

As projects within a state funded programme, the budget was generally secured in all projects for the whole time. However, a practitioner in HighCon pointed to a potential imbalance as research institutes get usually fully paid in such programmes while companies must cover 40% of the costs themselves. In HypoWave, one partner had to drop out when the funding officially ended even though there was still some potential for last important steps. Two participants of HypoWave pointed to the very formalised structures and requirements when being part of officially funded projects and the potential negative effects on e.g. the inclusion of informal actors or adaptations throughout the project.

Informal exchange

→ Communication among the participants beyond the formal channels.

While in all projects informal exchange was somehow mentioned as positive for the overall success, REMEMBER stands out in this regard. Here, it seemed to be key for the overall success. In this project as well as in in HypoWave, the project meetings took place at different locations which facilitated informal exchange.

Productive conflict

→ Controversial yet respectful discussions among the participants about the problem, solutions or the process.

This factor was hard to detect in the interviews. It was only mentioned implicitly by one interviewee from the HypoWave project when pointing to the importance of the formative evaluation applied that also allowed constructive criticism.

Project initiation by society

→ The initiation of a JKP project is steered by actors from society and not from academia.

None of the four projects was solely initiated by societal actors. In contrast, often the first formal steps were taken by researchers. However, these initiators such as the coordinators from HypoWave, HighCon or MULTI-

ReUse had a broad range of experiences and connections with societal actors such as wastewater treatment plant operators or plant manufacturers. Therefore, to a certain extent, they could include societal concerns already in the beginning. All societal actors that were interviewed implied also that they would not have been able to set up such a project to generate much needed results due to e.g. the lack of resources to do laboratory work themselves.

Recursiveness

→ Repeating key steps within a JKP process to ensure adaptiveness to new developments.

This factor was hard to detect. However, in HypoWave and HighCon interviewees pointed to the structural tendency – due to the funding requirements – of overloading projects with many and ambitious objectives. Recursiveness is then hard to realise given the numerous steps needed to reach the key goals.

Trustful collaboration

→ The participants can rely on each other's support.

By pointing to the presence of other factors such as intense *informal exchange* or *accountability*, interviewees from all projects then explained the presence and relevance of a trustful collaboration. They also often mentioned *previous collaboration* as supportive for realising trustful collaboration in the present projects.

Factors mentioned that were not included in the initial framework

When coding the interviews, several statements of interviewees in different projects could be translated in three further success factors that were not part of the initial framework.

Anticipatory project planning

Especially the coordinator from HighCon pointed to the necessity to start such projects "at the right time at the right place" (interview 1) to ensure

acceptance and commitment by the relevant stakeholders. Furthermore, he pointed to some difficulties regarding the compatibility of several technical components for the test plant and highlighted the need to ensure such harmonisation already in the beginning of projects. Also, interviewees from MULTI-ReUse and HypoWave emphasised that existing societal need ensured e.g. public attention for the results and interest by end-users such as farmers, municipalities or industry. These statements suggest anticipatory project planning functioning as an additional success factor.

Bilateral exchange

Interviewees from HighCon, HypoWave and REMEMBER emphasised the relevance of a good bilateral exchange between particular participants besides the joint communication moments. This was mentioned key in order to ensure e.g. the effective management of intersection points. Hereby, *trustful collaboration* and intense *informal exchange* could be identified as being closely related with bilateral exchange. Thus, *bilateral exchange* could be identified as an additional success factor.

Previous collaboration

In all projects, several partners had a common history of collaborations. It was explicitly mentioned by interviewees from all projects that this fact positively supported the presence of other factors such as *acknowledgement of differences*, *trustful collaboration*, or *informal exchange*. Furthermore, *previous collaborations* were mentioned as the cradle for new projects: "many projects are born out of […] leftovers from other projects […] or simply because some actors know each other" (interview 1). These observations made in the various projects suggest the existence of a success factor that can be conceptualised as *previous collaboration*.

5.3.3 Links between success criteria and factors

When building up the initial framework presented chapter 2, assumptions regarding links between factors and criteria were formulated (table 1). The findings of the case studies confirm most of the assumption. Table 22 comments on

assumptions made initially and adds several more assumptions based on the observations made in the case studies.[15]

Table 22: Links between Success Factors and Success Criteria (revised)

Factors	Salience	Credibility	Legitimacy
Boundary concepts			
Acknowledge-ment of differences	*↑ facilitates salient results for all*	*↑ facilitates credible results for all*	↑ pre-condition for inclusion of different perspectives *confirmed*
Balanced problem ownership			↑ prevents dominating actors *not confirmed but also not rejected*
Clear role distribution	↑ avoids conflicts that lower the quality of the results *not confirmed but also not rejected*	↑ avoids conflicts that lower the quality of the results *not confirmed but also not rejected*	↑ avoids that participants fall behind *not confirmed but also not rejected*
Joint goal definition	↑ ensures relevance of the knowledge for different participants *confirmed*	↑ ensures applicability of the knowledge for different participants *confirmed*	*↑ facilitates inclusion of different perspectives*
Joint problem definition	↑ ensures relevance of the knowledge for different participants *confirmed*	↑ ensures applicability of the knowledge for different participants *confirmed*	*↑ facilitates inclusion of different perspectives*

[15] Assumptions and comments based on the findings are written in *italic*. The original assumptions are written in standard.

Boundary objects			
Material boundary objects	*↑ concrete (end-) products can facilitate the salience of the process*	*↑ concrete (end-) products can facilitate the credibility of the process*	↑ facilitate inclusion of different perspectives *confirmed, but certain perspectives are hard to materialise and thus can still be left out*
Facilitators			↑ facilitate inclusion of different perspectives *confirmed*
Reward products for all	↑ ensures relevance of the results for different participants *confirmed*		
Boundary settings			
Accountability	↑ ensures that each participant contributes what is necessary to reach a certain level of relevance for all *confirmed*		
Balanced power relations			↑ prevents dominating actors *not confirmed, but also not rejected*
Broad actor coalition	↑ facilitates representation of relevant perspectives to reach salience for all in the first place ↓ too much participants can make the process very complex *confirmed*	↑ facilitates representation of relevant perspectives to ensure credibility in the first place ↓ too much participants can make the process very complex *confirmed*	↑ ensures representation of different perspectives in the first place ↓ too much participants can make the process very complex *confirmed*

Continuous participation	↑ facilitates a basic level of salience for all *confirmed*	*↑ facilitates credible results*	*↑ facilitates inclusion of perspectives*
Evaluation procedures	↑ ensures relevance of results throughout the process *confirmed*	↑ ensures applicability of results throughout the process *confirmed*	↑ ensures inclusion of different perspectives throughout the process *confirmed*
Flexibility	↑ facilitates a basic level of salience for all *confirmed*	*↑ facilitates credible results by adapting to changing circumstances*	
Funding			↑ ensures continuous inclusion of different perspectives *confirmed*
Informal exchange	*↑ can absorb lack of other factors relevant for salience*	*↑ can absorb lack of other factors relevant for credibility*	↑ adds another channel for including perspectives beyond the formal one *confirmed*
Productive conflict	↑ can increase the relevance by debating the key issues *not confirmed but also not rejected*		
Project initiation by society			↑ ensures the inclusion of non-academic perspectives *not confirmed, as non-academic perspectives were also be present despite researchers as initiators*

Recursiveness	↑ can increase the quality of the results and thereby their relevance *not confirmed, but also not rejected*	↑ allows to shift the focus throughout the project to ensure applicability for all *not confirmed, but also not rejected*	
Factors mentioned that were not included in the initial framework			
Anticipatory project planning	*↑ facilitates that results are salient*	*↑ facilitates that results are credible*	
Bilateral exchange	*↑ facilitates communication about key issues*	*↑ facilitates communication about key issues*	
Previous collaboration			*↑ facilitates inclusion of various stakeholders*

5.4 REVISED SUCCESS FRAMEWORK

Testing the initial success framework built up in chapter 2 with experiences made in the four cases on wastewater reuse in Germany confirmed generally the success factors suggested in literature. However, several specifications were possible based on the case studies. The following page visualises the revisions made by presenting the revised framework (figure 13) next to the initial framework (figure 12).

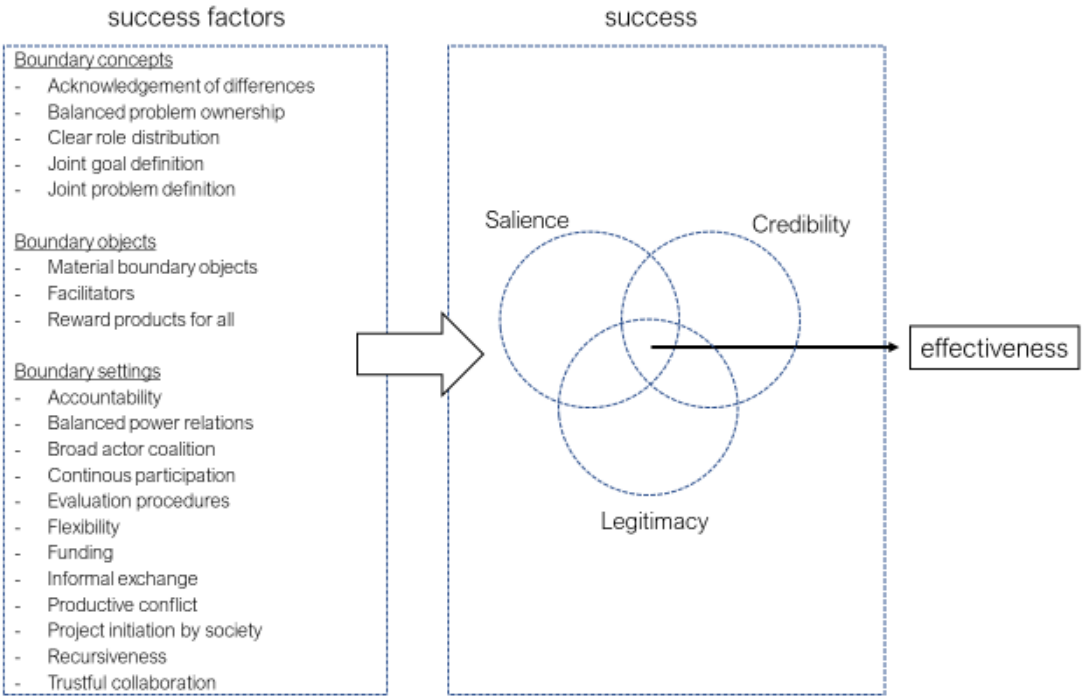

Figure 12: Initial Success Framework (copy of figure 5)

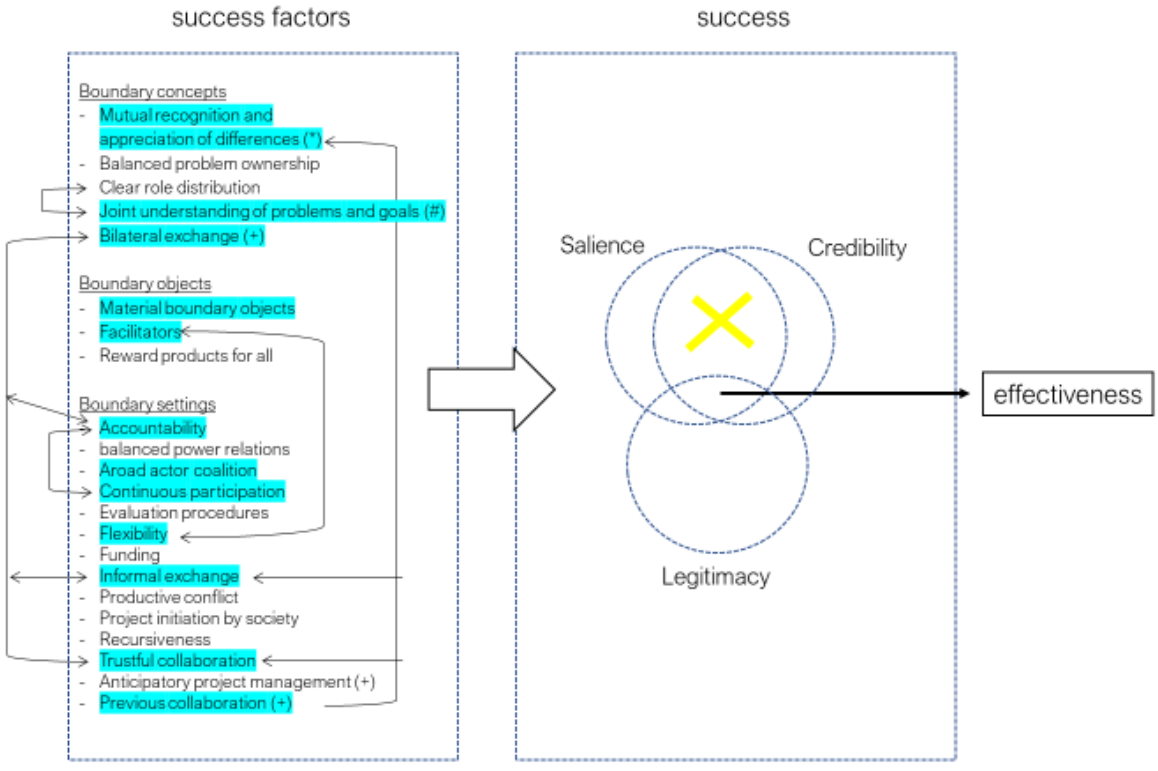

Figure 13: Revised Success Framework

Revisions made that are based on the empirical findings from the case studies are the following.

1. The overlap between the success criteria salience and credibility was extended (marked with a "x"). As shown in 5.3.1, the findings suggest that salience and the credibility of a knowledge system created within a JKP process tend to be positively correlated.

2. The factor acknowledgement of differences was renamed into mutual recognition and appreciation of differences (marked with a "*"). As shown in 5.3.2, acknowledgement without appreciation can hinder a successful process.

3. The factors *joint understanding of goals* and *joint understanding of problems* was merged into a single factor named *joint understanding of problems and goals* (marked with a "#"). As shown in 5.3.2, these two factors go hand in hand.

4. The factors *bilateral exchange*, *anticipatory project management* and *previous collaboration* were added (marked with a "+"). As shown in 5.3.2, these factors can also be relevant for success.

5. The factors *mutual recognition and appreciation of differences*, *joint understanding of problems and goals*, *bilateral exchange material boundary objects*, *facilitators*, *accountability*, *broad actor coalition*, *continuous participation*, *flexibility*, *informal exchange*, *trustful collaboration*, and *previous collaboration* are suggested as especially relevant for success (marked with colour). As shown in 5.3.2, each of these factors was relevant in at least three out of four cases.

6. The following correlations between factors are suggested (marked with "↔") based on the findings from 5.3.2.
    a. *Clear role distribution* and *joint understanding of problems and goals*.

b. *Continuous participation* and *accountability.*
c. *Flexibility* and *facilitators*.
d. *Trustful collaboration*, *informal exchange*, *accountability* and *bilateral exchange*.

7. It is suggested that *previous collaboration* supports the presence of *acknowledgement of differences*, *informal exchange* and *trustful collaboration* (marked with a "→") based on the findings from 5.3.2.

6 FINDINGS FROM THE EXPERT WORKSHOP

While the case studies tested the internal validity of the initial success framework, the expert workshop was conducted in order to assess the external validity and thereby answer sub-question c) *What degree of transferability do joint knowledge production experts from various empirical fields assign the findings based on wastewater reuse projects in Germany?*

To do so, the participants were confronted with generalised recommendations based on the core findings from the case studies (presented in 5.4) and were asked to evaluate the applicability of each recommendation to the kind of projects they are involved in. Hence, potential contextual factors that were intentionally left out in the case studies were discussed here explicitly.

This chapter retraces the expert feedback on the different recommendations. Section 6.1 presents the discussion on the findings in regard to the success criteria and section 6.2. focuses on the success factors. The results of the expert workshop are then brought together into a revised framework in section 6.3. Generally, the findings derived from the case studies were confirmed as being transferrable to other empirical domains. However, the relevance of the specific context of a project aiming for JKP was underlined by all participants.

6.1 DISCUSSING SUCCESS

Firstly, the written reactions of the experts on the case studies' findings in regard to the success criteria are presented. They are then discussed together with the verbal comments to highlight key findings from the workshop.

1. Salience and credibility often go hand in hand.

Participant	**Written Feedback in Mural**
Dhanush Dinesh	-

Dries Hegger	"Yes, but policymakers often want convincing evidence – not necessarily check all the details."
Femke Merkx	"not sure"
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"Intuitively I would say yes. Have no empirical prove."

2. It is more likely to have salient and credible results for all participants than legitimacy.

Participant	**Written Feedback in Mural**
Dhanush Dinesh	-
Dries Hegger	"Depends really on the contex[t] (co[o]perative/adversarial)."
Femke Merkx	-
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"Intuitively I would say yes. Have no empirical prove."

The six experts agreed in the verbal discussion that *salience*, *credibility* and *legitimacy* are appropriate criteria to assess success and thus effectiveness of processes of JKP for sustainability. The conceptualisation of JKP as creating a knowledge system was confirmed in that JKP should be understood as a learning process rather than a project with clear materialised end-products. Ensuring *salience* of the results for all participants was mentioned as most important by pointing to the different contexts participants work in. Here, the term *operational misfit* (Van Enst et al., 2014) was introduced to conceptualise the varying and sometimes conflicting expectations of science and practice in regard to what results count as relevant. It was emphasised that even when the participants themselves

are benefitting from a JKP process, their superiors or organizations might not award this necessarily. Also, when clear project targets are formulated, they must be met when aiming for success even though they might not always foster salience, credibility or legitimacy.

Furthermore, the dependency of the success evaluation on the unit of analysis and time frame was discussed. For example, project results in the form of learnings made through the process can lead directly or with some time delay to solving a specific sustainability problem. Stable patterns among the three criteria could not be confirmed by the experts. While the case studies suggested a positive correlation between *salience* and *credibility* as well as generally higher scores of these two criteria compared to *legitimacy*, this was rather seen as context-dependent.

6.2 DISCUSSING SUCCESS FACTORS

Firstly, the written reactions of the experts on the case studies' findings in regard to the success factors are presented. They are then discussed together with the verbal comments to highlight key findings from the workshop.

1. A project leader (or intermediary actors) that is skilled in trans-/interdisciplinary work and/or knows about the different subjects enhances the likelihood of success in JKP processes.

Participant	**Written Feedback in Mural**
Dhanush Dinesh	-
Dries Hegger	"This one is crucial – participatory processes often come down to people."
Femke Merkx	"yes"
Frank van Laerhoven	-
Madelon Eelderink	"It can help […] yet on the other hand it can also be a pitfall […] if an action researcher knows too much about the subject then it could also be that he forgets to ask certain questions […]."
Ymkje de Boer	"yes"

2. Ongoing evaluation procedures that control whether the integration of different perspectives takes place as planned enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"In my experience challenge is to choose wisely between formative and summative evaluation"
Femke Merkx	"yes, though I prefer the term monitoring instead of evaluation. Things will not go as planned, so it's more about constantly reflecting and adjusting"
Frank van Laerhoven	"Very important. Constant, iterative, back and [forth] learning is key." "Monitoring, evaluation and learning is one of the key aspects in research uptake strategies, I think"
Madelon Eelderink	-
Ymkje de Boer	"Yes." "I agree with Femke that monitoring would be a better term."

3. A trustful atmosphere among the participants, especially when the project lead or other procedures are not ideal, enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	"Trust is certainly important, but to answer the comment on how to create trust, you may want to flag this in Point 2, i.e. processes to bring accountability."
Dries Hegger	"Can be challenging - JKP is embedded in existing governance process - with virtuous or vicious cycles of trust/distrust"
Femke Merkx	-
Frank van Laerhoven	"But how to create trust?"
Madelon Eelderink	"It is important […] to share the truth, [but] how hard is it to share the truth."
Ymkje de Boer	"Yes, circumstances are rarely ideal; people have to be open and flexible, prepared to make mistakes and deal with uncertainty"

	"Working with cities means dealing with uncertainties in f.i. the political field. Living labs can be put off suddenly, people change jobs and so on... Always have a Plan B and a Plan C"

4. An effective bilateral exchange between the participants (and not only joint knowledge production with the whole team) enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"This is really contingent upon the specifics and context of a project. But in general[,] intensive and frequent interaction seems to be helpful."
Femke Merkx	"yes"
Frank van Laerhoven	"subject to provision dilemma: private costs vs shared benefits."
Madelon Eelderink	"it is more realistic"
Ymkje de Boer	"I guess so. I know it happens a lot in projects, esp. PhD[-]projects"

5. An acceptance of the relevance of the different perspectives (not only acknowledgement) from the beginning enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	"Isn't this the same as legitimacy as proposed by Cash et al.?"
Dries Hegger	"Dutch cca (climate change [adaptation]) projects: all water managers who are more or less on the same page. Then things become easy - but how to work in a more adversarial context?"
Femke Merkx	-
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"Yes"

6. Concrete and abstract boundary objects such as a test plant and publications written together enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"In context of CCA (climate change [adaptation]): Bridging concepts, tools, serious games, interactive maps, climate services"
Femke Merkx	-
Frank van Laerhoven	"For academics publications mean the world. For practitioners? Mwa.." "Divergent incentive structures may prevent meaningful collaboration"
Madelon Eelderink	-
Ymkje de Boer	"Yes"

7. A clear leading question and objective to steer the process enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"Problem scoping – moving from 100 [practical] questions to 5 researchable questions, is important. - in Knowledge for Climate a lot of time was reserved for that. – Rob Hoppe's writings also stress importance of good problem scoping."
Femke Merkx	"Not sure as these may develop t[h]roughout the process"
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"Yes, but be open to change in that"

8. An anticipatory project design that puts the process in the right time and place enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"But also: adaptive - difficult to make projects adaptive, if researcher working on them are e.g. PhDs - chance of operational misfit."
Femke Merkx	"not sure what is meant exactly"
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"I guess so, but I'm not sure was it meant"

9. The more actors, the higher the demand for sophisticated project management in order to enhances the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	"Sophisticated project management often makes this more complicated, in my experience."
Dries Hegger	"Yes, and most challenging is to make a wise choice for whom to include and whom to exclude."
Femke Merkx	-
Frank van Laerhoven	-
Madelon Eelderink	-
Ymkje de Boer	"Not sure, with less participants it [is] also important. But yes, with more you have to take more time to keep people involved."

10. Previous collaboration can facilitate the joint knowledge production process and thereby enhance the likelihood of success in JKP processes.

Participant	Written Feedback
Dhanush Dinesh	-
Dries Hegger	"Definitely - links to the point of trust. Armitage et al. 2011 also wrote about this."

Femke Merkx	-
Frank van Laerhoven	"Agree. Working together is something you can learn. [You] can become better at it. Developing a reputation of being a trustworthy collaborator helps."
Madelon Eelderink	-
Ymkje de Boer	-

The following pages summarise the discussions in the workshop for each factor.

Boundary concepts

→ Non-physical terms, definitions, visualisations or the alike that facilitate the communication within a process of JKP.[16]

Acknowledgement of differences:

→ Explicit recognition by all participants within a particular JKP process that the different stakeholders may have a different understanding of the problem, the solution and differing reasons to be concerned.

The experts generally confirmed the relevance of this factor. Based on experiences made in climate change adaptation projects one researcher suggested that the likelihood of mutual recognition and acceptance is itself also dependent on the specific context of a project. He mentioned the example of Dutch water managers who are often on the same page. Here, mutual recognition can be easier compared to a more controversial setting. Also, the potential overlap between this factor and the criterion legitimacy was mentioned.

Balanced problem ownership

→ All participants can bring in their specific concerns and nobody is dominating the process.

[16] The definitions of the various success factors (indicated with "→") were originally developed in section 2.2.2 and are repeated here to contextualize the findings for to each factor. Only the factors *bilateral exchange*, *anticipatory project planning* and *previous collaboration* were developed in chapter 5 based on the findings of the case studies.

Not explicitly discussed

Clear role distribution

→ Every participant is aware of what his or her own task is to contribute to the project goals.

Not explicitly discussed

Joint understanding of problems and goals

→ The participants communicate about and agree on problems to be tackled and objectives to be reached within the JKP process.

While the experts generally saw the necessity of having a red line throughout the project, they also emphasised the need to adapt the leading questions within the process. Also, the potential of finding common ground was suggested as dependent on the specific project context.

Bilateral exchange

→ Communication between individual participants.

The importance of interaction on many levels including the bilateral was confirmed by most experts. While the notion of joint knowledge production might suggest images of all stakeholders sitting in a circle and deliberating like in ancient Athens, one experts pointed to the reality gap here. Rather, she argued, JKP production consists of many, many bilateral interactions that sometimes add up to a group discussion. In her words: "bilateral exchange is more realistic […] it is a utopia that all come together and make joint knowledge production together" (Madelon Eelderink). However, another expert pointed to the "provision dilemma" (Frank van Laerhoven) when it comes to communication as the costs are private, but the benefits might be shared.

Boundary objects

→ Material objects or human subjects that allow acting within a JKP process by offering points of contact for the different contributions of different actors.

Material boundary objects

> → Material objects or devices that are graspable and foster the different participants to contribute components that make the overall object complete or working.
>
> For the context of climate change adaptation, serious games or interactive maps were given as examples here.[17]

Facilitators

> → Participants within the project that mediate between different perspectives, solve conflicts, coordinate tasks or make decisions in critical moments. These facilitators can be either officially assigned for such role or assume this function more informally.
>
> While there was an agreement on the key function facilitators have for JKP, it was noted by several experts that e.g. a coordinator with high expertise on the subject or a very sophisticated management approach might impede an inclusive process. Also, without a certain level of accountability by all participants even a very skilled facilitator might struggle.

Reward products for all

> → Concrete material or immaterial things that translate the results in products that are perceived as useful in the respective working contexts of different participants.
>
> In line with the emphasis on salience as a key success criterion, the participants also highlighted the need to produce results that are beneficial for each. However, one expert pointed to the risk of having different incentive structures which in turn could foster parallel processes.

[17] Arguably, these suggestions could also be defined as boundary concepts.

Boundary settings

→ Settings, including the number of participants or evaluation procedures, that allow a fruitful context in which the boundary concepts and objects can be developed.

Accountability

→ Basic level of responsibility for the project that is shared among all participants.

In alignment with *mutual recognition and appreciation of differences* and building up a *joint definition of goals and problem*, accountability of all participants in a JKP was discussed by the experts as a reciprocal process. A certain commitment is necessary for a good JKP process, however, if stakeholders feel not included in the first place, their commitment might also be rather weak or even confrontative.

Balanced power relations

→ Given that different participants have different levels of resources, authority or leverage in different contexts, nobody should have a disproportionately high influence within a JKP process.

Not explicitly discussed

Broad actor coalition

→ An actor coalition that brings together all relevant stakeholders while not exceeding a manageable number of participants.

One expert mentioned here that the higher the number of relevant stakeholders, the more difficult the choice is of who is to be included and who not.

Continuous participation

→ All relevant stakeholders are involved and present throughout the JKP process.

Not explicitly discussed

Evaluation procedures

→ Formative evaluation throughout the JKP process in order to identify and address unexpected or undesired developments.

The experts agreed unanimously on the relevance of this factor to ensure constant learning and adjusting in the process. Here, monitoring was suggested as an alternative term. Also, a conscious decision between applying formative evaluation (during the process) and summative evaluation (after the process) was proposed.

Flexibility

→ Flexibility in time, content and methods throughout the JKP process to adjust to unexpected or undesired developments.

Building on experiences e.g. JKP for climate change adaptation or sustainability, flexibility was suggested as a key factor to deal with uncertainties and the rarely ideal circumstances in such projects. Hereby, flexibility was highlighted by the experts as a singular factor and as a necessary attribute when putting the other success factors in place. For example, also the *joint understanding of problems and goals* should be rather an adaptive process throughout the project instead of a static decision. However, it was noted that a continuously changing project can also bring difficulties with it for e.g. PhD researchers that need to stick to their proposed research.

Funding

→ Secured funding throughout the process.

Not explicitly discussed

Informal exchange

→ Communication among the participants beyond the formal channels.

Not explicitly discussed

Productive conflict

→ Controversial yet respectful discussions among the participants about the problem, solutions or the process.

Not explicitly discussed

Project initiation by society

→ The initiation of a JKP project is steered by actors from society and not from academia.

Not explicitly discussed

Recursiveness

→ Repeating key steps within a JKP process to ensure adaptiveness to new developments.

Not explicitly discussed

Trustful collaboration

→ The participants can rely on each other's support.

While the experts agreed that trust among the participants contributes to success, they pointed to the varying likelihood to build up trust in the first place. Here, the existing governance context and existing encounters can facilitate or hinder the trust building in a particular project. Having a trustful collaboration then can also facilitate the *mutual recognition and acceptance of differences*.

Anticipatory project planning

→ Project planning that takes into account potential future development.

Not explicitly discussed

Previous collaboration

→ Participants with a common project history.

Several experts could confirm with their experience. It was suggested that previous collaboration not only enhances *trustful collaboration* but also that the more experience actors have in JKP the better they can become.

6.3 CONTEXTUALIZING THE REVISED FRAMEWORK

Confronting the framework revised with findings from the case studies (figure 14) with the experiences of experts for JKP led to several adjustments visualised in the figure 15.

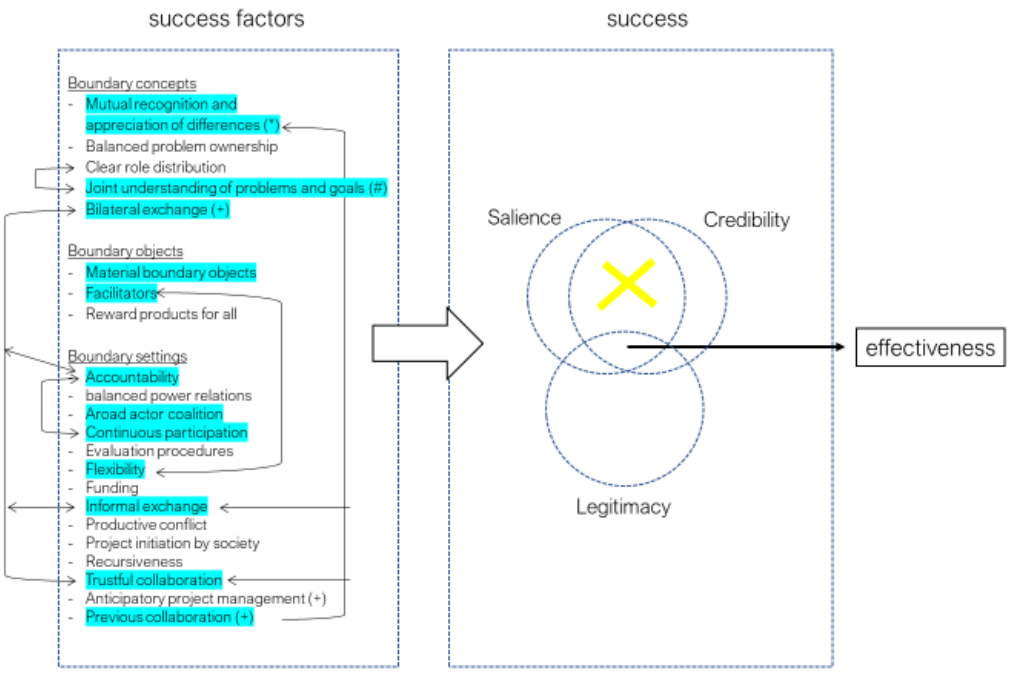

Figure 15: Revised Success Framework (copy of figure 13)

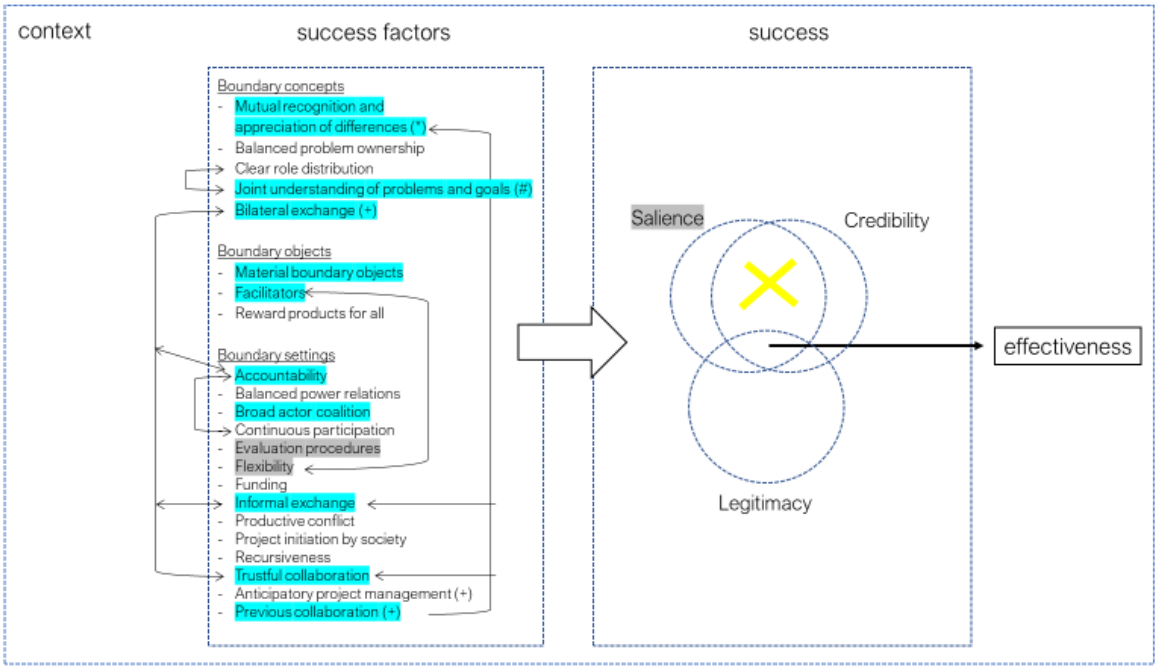

Figure 14: Contextualising the Revised Success Framework

1. The expert workshop confirmed the adequacy of measuring successful JKP with the criteria salience, credibility and legitimacy. The relevance of salience for success was highlighted (marked in colour). However, the big challenge of ensuring salience for all was also emphasised by pointing to the potential operational misfit of the working contexts of the different participants.

2. The expert workshop generally confirmed the transferability of the findings in regard to the success factors from the case studies to their respective fields of work. They emphasised in particular the relevance of factors such as *evaluation procedures* and *flexibility* given the uncertain, changing and not-ideal context JKP is often embedded in (marked in colour).

3. The expert workshop suggested that the question of whether a JKP process is evaluated as success or not is also dependent on what is evaluated and when (marked with the context-frame).

4. The expert workshop confirmed the relevance of *bilateral exchange* by pointing to the unrealistic idea of JKP happening when everybody comes together to talk to everybody. Instead, JKP can be understood as a messy process in which manifold interaction on many levels take place (not marked explicitly).

5. The expert workshop suggested to conceptualise success factors not as purely independent variables but as themselves partly dependent on contextual factors. Existing governance structures, previous encounters of participants or the number of relevant stakeholders can all enhance or impede the likelihood of realising factors such as *mutual recognition and appreciation of differences*, *joint definitions of problems and goals* or *trustful collaboration* (marked with the context-frame).

7 DISCUSSION

This chapter discusses the key findings of this research (section 7.1), places them back in literature (7.2), points to several limitations of the research approach taken (7.3) and suggests potential for further research (7.4).

7.1 DISCUSSING THE FINDINGS

Confronting a success framework derived from literature on JKP for sustainability with case studies on water reuse projects in Germany and discussing the subsequent findings in a workshop with various experts for JKP in different fields resulted in an empirically robust success framework for JKP. Figure 16 visualises this framework that suggests a set of success factors to increase the likelihood of salience, credibility and legitimacy of the knowledge produced in such a process.

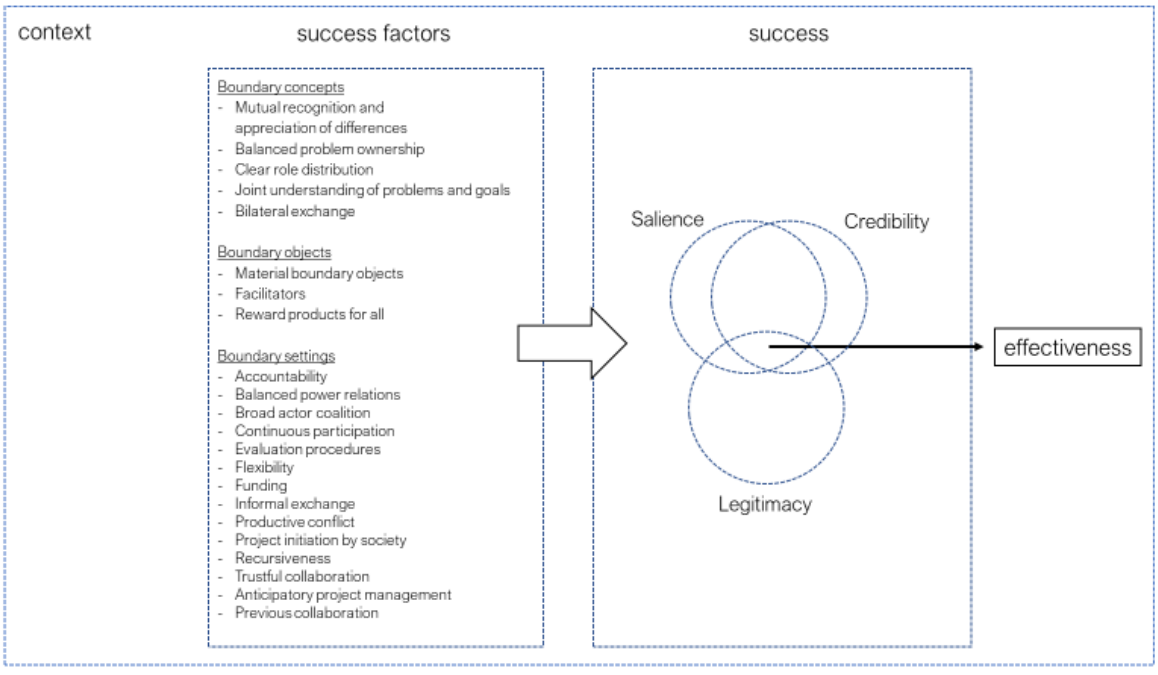

Figure 16: Final Success Framework for JKP

This success framework contributes to the academic debate as well as to attempts of applying JKP in empirical situations by proposing success factors with high internal and external validity. This high validity was reached by conducting various complementary theoretical and empirical steps: conceptualising JKP (section 2.1), synthesising relevant findings from literature (section 2.2), testing

them with four cases of JKP in a particular empirical field (chapter 5) and ensuring the transferability of these empirical findings with an expert workshop (chapter 6).

Several key findings provide JKP practitioners with the possibility to focus on certain leverage points within such a process. Firstly, several factors proved to be of particular relevance in the case studies: *acknowledgement of differences*, *joint understanding of problems*, *joint understanding of goals*, *facilitators*, *material boundary objects*, *facilitators*, *accountability*, *broad actor coalition*, *continuous participation*, *flexibility*, *informal exchange*, *trustful collaboration*, *bilateral exchange* and *previous collaboration.* Also, the expert workshop suggested *salience* as the success criterion that deserves most attention. Thirdly, by repeatedly discussing each factor in detail throughout his paper – when defining them based on literature (see section 2.2.2), when confronting them with the empirical cases (see section 5.3.2), and when adding experiences from experts (see section 6.2) – it is shown that success factors are no one-size-fits-all solutions but instead can be of different use under different empirical circumstances. Thus, success framework developed gives guidance without pretending to be a panacea. Here, the *context* part in the framework points to the fact that success factors themselves depend to a certain degree on governance structures, previous encounters or organizational contexts. This allows potential applicants of the framework to identify at an early stage potentials and obstacles for realising the success factors and subsequently a successful JKP. Fourthly, *flexibility* or adaptiveness as a recurring motive in the case studies and in the workshop suggests itself as being more than a singular success factor. Rather, it can be seen as a cross-cutting theme that matters for all factors. For example, the *joint goal and problem definition* or the work of *facilitators* also require a high level of flexibility or adaptiveness given the uncertainties, changing conditions and nonideal circumstances that often characterize the context of JKP projects for sustainability.

Thus, the findings of this research suggest a success framework that is specific enough to give concrete guidance while being open enough to let actors involved in JKP adapt the success factors to the particular context they are working in.

7.2 PLACING THE FINDINGS BACK IN LITERATURE

The findings produced in this research add evidence to similar empirical assessments of success factors done by Hegger & Dieperink (2014) or Luthe (2017). Regarding the success factors, the findings of this research add several insights to those previous contributions. For example, derived from existing literature could be further specified. Moreover, the work presented here conceptualises *bilateral exchange*, *anticipatory project management* and *previous collaboration* as success factors; elements that earlier contributions did not cover. Also, the list of factors suggested in this research is more extensive compared to Hegger & Dieperink (2014). Their work does not explicitly cover factors such as *flexibility*, *informal exchange*, *trustful collaboration*, *bilateral exchange* and *previous collaboration* that proved to be relevant in this research. Also, "presence of specific resources: boundary objects, facilities, organizational forms, competencies" (Hegger & Dieperink, 2014: 11) is presented as a single factor without further distinction. In contrast, the 22 success factors conceptualised in this work show a higher level of detail regarding the specific boundary objects or settings that can increase the likelihood of success. Moreover, Hegger & Dieperink (2014) categorised their list of success factors alongside actors, discourses, rules and resources while Luthe (2017) organised his findings alongside three phases and general principles. In this work, the concept of boundary work developed by Mollinga (2010) was used to structure the success factors. While the choice of Luthe (2017) provides practitioners with a clear hint for where and what to start with, it implies a to a certain degree standard procedure, which is questionable. Similarly, Hegger & Dieperink (2014) imply to focus on actors, discourses, rules and resources. In slight contrast, the structuration used in this research tries to shift the focus away from conventional categories such as phases or actors towards the boundary areas that are identified as the key for developing solutions for complex sustainability challenges.

Furthermore, the results of this research corroborate with cross-cutting topics in sustainability literature such as complexity, adaptiveness or uncertainty. For example, the detected relevance of flexibility *in* JKP processes with adaptivity as

an important aim *of* JKP, as outlined by Armitage et al. (2011), provides space for further conceptual elaboration. Also, the identification of *anticipatory project planning* in the case studies as an additional success factor relates well with the findings from Luthe (2017) that suggest a thorough time investment before the actual project start. The potential contextual barriers mentioned in the expert workshop suggest the need to build up *trustful collaboration,* a crucial theme also faced by Armitage et al. (2011) when analysing JKP in the artic region.

Regarding the success criteria, it is noteworthy that the findings from the case studies partly contradict the conceptualisation of success suggested by Cash et al. (2003). When developing *salience*, *credibility* and *legitimacy* as success criteria, these scholars point to the fact that trade-offs among the criteria exist. For example, increasing salience can lead to decreasing legitimacy (Cash et al., 2003). The empirical findings of this research suggest the contrary. Throughout all cases, salience and credibility of the results seemed to overlap to a high extent for the participants. Furthermore, the partial exclusion of one participant in the MULTI-ReUse project that lowered the legitimacy tremendously, also made it hard for the participant to ensure a certain level of salience and credibility of the results. Hence, this research provides evidence for a positive instead of a conflictive correlation of the three success criteria.

7.3 CRITICAL REFLECTION OF THE RESEARCH APPROACH

Several conceptual and methodological aspects of the chosen research approach limit the significance of the results for the scientific debate on productive science-policy interactions as well as their potential applicability in practice.

Measuring empirically the degree of the three success criteria salience, credibility and legitimacy was challenging. Not only was it difficult to operationalise the criteria, but also basing their evaluation on the participants' perception created room for potential biases. For example, the active involvement in one of the investigated projects was a necessary pre-condition to express concerns on legitimacy in the first place. Putting it differently, if a relevant stakeholder was excluded from the project, the research approach chosen here could not grasp this

as a fact that lowers the legitimacy and thereby the success of the particular project. Furthermore, there was the risk of an overly positive evaluation of success by the interviewees for different motives: not wanting to evaluate too negatively their own work, fearing negative public image when their opinions are published, or fearing to step on each other's feet which can have negative consequences on future collaboration. However, the fact that two of the projects – HighCon and MULTI-ReUse – were awarded for their achievements indicates that the participants of at least these two projects did not whitewash their own work.[18] Finally, testing factors suggested in literature via interviews always carries the risk of approaching the interviewees with suggestive questions, therefore making the factors to be tested a self-fulfilling prophecy. However, such limitations are not specific to this research but rather present a general challenge to qualitative research.

The broad definition of JKP applied here allows a high divergence of projects that fit under the term. Arguably, the group of actors in the researched projects can be characterised as rather homogenous as most of them had a technology-oriented perspective. This is not surprising as the funding programme they were embedded in called for the development of new technologies for wastewater reuse. However, a more diverse actor coalition might have produced different results. This became especially apparent when the only social-ecological actor in two projects had a very different view on whether the projects were successful in realising JKP. The application of a very broad concept such as JKP acknowledges that there is no single best way to realise productive science-policy interactions. It also lowers the barrier for realising concrete projects as only few but key criteria must be fulfilled in order to frame it as JKP. However, some richness and nuances of underlying approaches such as transdisciplinary research are then left out. Hence, a more

[18] Award for HighCon:

https://www.watershare.eu/watershare-news/highcon-receives-iwa-resource-recovery-cluster-best-practice-award-for-closed-loop-industrial-wastewater-systems/

Award for MULTI-ReUse:

https://www.metropolregion-nordwest.de/portal/meldungen/papierflieger-landet-im-landkreis-wesermarsch-oowv-gewinnt-nachhaltigkeitsaward-nordwest-2020-900000235-10018.html?rubrik=900000005

elaborated conceptualisation of how different research approaches for productive science-policy interactions such as JKP, transdisciplinary research, participatory action research (see e.g. Eelderink et al., 2020), mode-2 science or post-normal science relate to each other could be valuable here. Some first important steps in such a direction have been made by van Enst et al. (2014) by suggesting a consistent research agenda towards productive science-policy interfaces as well as by Bremer & Meisch (2017) by reviewing different modes of co-production in climate change research. These articles provide structured insights into the potentials and limitations of various approaches, which governance levels they apply to, and who are key stakeholders. Further developing these insights can allow a more purposeful engagement in productive science-policy interfaces by allowing a conscious decision about which approach is most suitable for which problem.

Furthermore, this research clearly suffers from a theoretical and empirical perspective that is limited to scientific debates and empirical experiences in the Global North. Indeed, the experts participating in the workshop also brought in experiences mad in Global South countries. However, the literature used to build up the initial framework is heavily dominated by Western perspectives. This in turn points to a huge bias in JKP literature in general. Of course, using literature and case studies focusing on Western countries with concepts developed mostly in Western countries does not automatically lead to a low significance of the results for JKP in the Global South. However, stepping back and applying a critical post-colonialist perspective on this research – and the debate it is embedded in – makes the conceptual and empirical blind spots apparent.

7.4 POTENTIAL FOR FOLLOW-UP RESEARCH

When bringing together the significance of the findings of this research discussed in section 7.1, their connection with existing literature (section 7.2) and the limitations of the approach taken (7.3), several points of contact for further research become apparent.

First and foremost, continuing empirical confrontation of the framework with experiences in a variety of sustainability domains and societal contexts can strengthen the significance of the success factors as well as provide more insights on how the context itself facilitates or hinders the presence of certain factors. Given the lack of Global South perspectives both in theoretical and empirical contributions, empirical research by researchers situated in such countries can delineate the empirical limitations and potentials of the findings suggested here. Also, testing the framework in a similar geographical context (Germany) but for a different sustainability field (e.g. energy) can show the degree of transferability of the findings to fields other than water. Similarly, applying the framework to wastewater reuse projects in other countries helps to estimate the influence of the geographical context on the success factors.

In relation to this, a more elaborate theoretical conceptualisation and empirical specification of adaptiveness as a cross-cutting theme for JKP is needed. Also, the further developed conceptualisation of successful joint knowledge production as a knowledge system in which different epistemes meet, and which can be characterised with a simultaneously high degree of salience, credibility and legitimacy for all participants, deserves some more testing and development. For example, the implication of creating a knowledge system within JKP that substitutes an existing unsuccessful one could be discussed together with the context-dependency of the success factors as well as the dependency of success on what exactly and when it is evaluated. Here, also a clearer incorporation of power structures that limit or facilitate certain actors in the process is required.[19] For example, an analysis of the discourses around the problem at hand in a specific societal context can reveal better existing power lines. Also, a critical legal analysis of who has what kind of access to e.g. contested natural resources can provide valuable insights about whose concerns have a higher chance to be heard.

Findings in this research suggest that JKP among science and society works well as long as it is limited to a certain discipline or perspective (e.g. technology-

[19] Even though *balanced power relations* was suggested as one success factor in the initial framework, it was hard to detect existing power relations in the projects and how the influenced the process.

oriented). Instead, problems arise when an actor brings in a very different view, regardless whether it is an academic or practitioner. This raises the important research question of whether the challenge in JKP lies more in bridging science and society or rather in bridging different focus-areas.

Also, empirical studies are needed on whether a simultaneously high degree of salience, credibility and legitimacy of a knowledge system constructed within a JKP process indeed leads to effectiveness in solving the actual problem. Even though it is difficult to draw causal relationships between concrete JKP projects and potential improvement of the respective sustainability issue, methods such as discourse analysis allow at least to retrace the development of a certain knowledge system of a particular area. Also, to prove effectiveness, the inclusion of concrete data on e.g. quantity or quality of water is possible. Thus, there is a great potential for future interdisciplinary and transdisciplinary work for evaluating empirical effectiveness of concrete JKP efforts.

On a broader scheme, a critical self-reflection within the research domain on JKP for sustainability is necessary that asks why the debate does not yet sufficiently include voices beyond Global North academic institutions.

8 CONCLUSION

Facing complex, urgent and dangerous sustainability challenges such as climate change or water scarcity, productive science-policy interactions are seen as one way to generate much needed knowledge for appropriate solutions. Aiming for a meaningful contribution to the existing debate on how to realise a fruitful interaction between scientific and societal perspectives by applying JKP, this research was driven by the question: **Which generalisable factors that increase the likelihood of successful joint knowledge production for sustainability can be developed from the empirical context of wastewater reuse projects in Germany?**

The produced results confirm previous contributions and add further insights by suggesting the following generalisable factors as increasing the likelihood of successful JKP: *mutual recognition and appreciation of differences*, *balanced problem ownership*, *clear role distribution*, *joint understanding of problems and goals*, *bilateral exchange*, *material boundary objects*, *facilitators*, *reward products for all*, *accountability*, *balanced power relations*, *broad actor coalition*, *continuous participation*, *evaluation procedures*, *flexibility*, *funding*, *informal exchange*, *productive conflict*, *project initiation by society*, *recursiveness*, *trustful collaboration*, *anticipatory project management* and *previous collaboration*. In other words, this research argues that ensuring these factors leads to rather successful science-policy interactions in the form of JKP and thereby contribute to solving pressing sustainability problems.

Studying four cases of JKP for wastewater reuse in Germany confirmed the relevance of success factors extracted from pertinent literature for this particular empirical context. Also, correlations among certain success factors and an unexpected overlap between the success criteria salience and credibility were detected when conducting interviews with participating actors. A complementary expert workshop, in which researchers and practitioners shared their experiences from a variety of JKP processes in different fields and countries, generally confirmed the transferability of these success factors to other empirical contexts. However, the context-dependent potentials and obstacles to ensure these factors

in the first place were pointed out by referring to the differing governance structures a particular JKP project can be embedded in.

Building upon the findings of this research, a systematised, empirically tested and validated success framework is proposed as a concrete output that can serve as a guiding tool for future JKP attempts. By suggesting points of leverage while emphasising their context-dependency, researchers and practitioners aiming for JKP can use the findings developed in this research as an adaptive framework that is applicable to a significant extent to their specific project; the latter by being specific enough to be meaningful but open enough to leave room for interpretation and adaptation.

The starting point of this research was the twofold complexity of both sustainability problems and appropriate solutions. This complexity is likely to increase with a rising number of social, economic and ecological factors and interdependencies that are identified as relevant for solving these challenges. At the same time, there is no doubt that climate change, water scarcity and biodiversity loss demand immediate and consequent action. The success framework for joint knowledge production developed in this research can support concrete attempts that aim to tackle these complex problems.

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ANNEX

I: ANONYMISED LIST OF INTERVIEWS

No.	Project	Interviewee(s)	Date
1	HighCon	Project coordinator and researcher at a university (focus on environmental process engineering)	20th May 2020
2	HighCon	Researcher at a university (focus on nanofiltration fouling, scaling)	28th May 2020
3	HighCon	Practitioner at a plant manufacturer (focus on research and development)	16th June 2020
4	HypoWave	Researcher at an independent research institute (focus on social-ecological dimensions of water)[20]	27th May 2020
5	HypoWave	Researcher at a university (focus on water reuse for agricultural purposes)	26th May 2020
6	HypoWave	Practitioner at a public operator of a wastewater treatment plant (focus on laboratory work)	26th May 2020
7	MULTI-ReUse	Project coordinator and researcher at an independent research institute (focus on process engineering)	06th May 2020
8	MULTI-ReUse	Practitioner at a public operator of wastewater treatment plants (focus on innovation)	27th April 2020
9	MULTI-ReUse	Practitioner at a public operator of wastewater treatment plants (focus on technical development)	13th May 2020
10	MULTI-ReUse	Researcher at an independent research institute (focus on social-ecological dimensions of water)	27th May 2020
11	REMEMBER	Project coordinators and practitioners at a plant manufacturer (focus on technical development of filters)	11th May 2020
12	REMEMBER	Researcher at a university (focus on use of plasma)	25th May 2020

[20] Same person like in interview 10.

II: INTERVIEW GUIDE

Formales

Dauer: 30 – 60 min.
Kanal: Telefon, Skype, Teams, Zoom
Anzahl Interviewte pro Interview: 1
Methode: Semi-strukturiertes Interview

Ziele:

1. **Herausfinden, ob verschiedene Teilnehmer*innen das Projekt als erfolgreich ansehen.**
    a. Herausfinden, woran sie das festmachen
    b. Herausfinden, ob sie das eher an konkreten Endprodukten oder dem Prozess festmachen (process, product,output, outcome, impact)
    c. Herausfinden, ob die Resultate nach ihren Maßstäben als relevant (salient), glaubwürdig/belastbar (credible) und legitim (legitime) ansehen.
2. **Herausfinden, welche Faktoren als relevant für Erfolg (oder Misserfolg) angesehen werden.**
    a. Herausfinden, ob die aus der Literatur gezogenen Faktoren als relevant angesehen werden.
3. **Herausfinden, ob es Muster zwischen Erfolgsfaktoren und -kriterien gibt**
    a. Herausfinden, ob bestimmte Faktoren immer gemeinsam auftreten bzw. eine bestimmte Kombination schon ausreichend für Erfolg ist
    b. Herausfinden, ob bestimmte Faktoren eher zu einem bestimmten Erfolgskriterium beitragen (bspw. Vertrauen → Legitimität)
    c. Herausfinden, ob bestimmte Faktoren zu Synergien zwischen den Erfolgskriterien beitragen

Generelle Vorgehensweise

1. Trigger-Fragen stellen, dann mögliche Nachfragen
2. Nach Beispielen fragen
3. Nach Verbesserungsmöglichkeiten fragen
4. Keine Entweder-Oder-Fragen

Beginn:

1. **Kurze Vorstellung meiner Person und meiner Masterarbeit**

2. **Kurze Darstellung, an was ich interessiert bin**

3. **Kurze Aufklärung, wie ich die Informationen verwende**

4. **Kurze Abfrage, ob ich das Gespräch aufnehmen darf**

Mögliche Fragen:

Einführung

1. **Sie sind XXX und arbeiten bei YYY, richtig?**
2. **Laut Homepage war die Zielsetzung XXX. Ist das richtig?**
3. **Meines Wissens nach war Ihre Rolle/ die Ihrer Organisation XXX. Ist das richtig?**
4. **Was hat sich Ihre Organisation von dem Projekt erhofft?**

Erfolgskriterien

5. **War das Projekt aus Ihrer Sicht erfolgreich oder eher nicht?**
    a. Haben Sie Beispiele?
    b. Was ist denn ‚rausgekommen'?
    c. Woran machen Sie Ihre Einschätzung fest? (Produkte, Prozesse / Kriterien)
    d. Gab es etwas, das nicht so lief wie geplant?
    e. Sind die Projektresultate für Sie bzw. Ihre Arbeit/Organisation hilfreich, sprich
        i. relevant (salient),
        ii. belastbar → würde Sie Entscheidungen daran ausrichten (credible)
        iii. und berücksichtigen ihre spezifische Perspektive (legitime)?

Erfolgsfaktoren allgemein

6. **Woran lag es aus Ihrer Sicht, dass das Projekt nicht erfolgreich/erfolgreich verlaufen ist?**
    a. Haben Sie Beispiele?
    b. Welche Faktoren haben dazu beigetragen, dass die Projektresultate für Sie relevant (salient) / belastbar (credible) / legitim (legitime) ist?

Boundary Concepts

7. **Wie wurde eigentlich festgelegt, was das Problem/Thema war und wie die Lösung aussehen konnte?**
    a. Hatten Sie alle ähnliche Erwartungen bzgl. des Projekts?
    b. Wie relevant war bzw. ist das Problem für Sie?

Boundary Objects

8. **Hatten Sie Hilfsmittel, um besser kommunizieren zu können bzw. um Problem zu definieren / Lösung zu entwickeln? Bspw. Modelle, Grafiken, etc.**
    a. Wie hat die Projektleitung ihre Rolle ausgefüllt?
    b. Haben einige den Prozess mehr dominiert als andere?
    c. Gab es Konflikte?
    d. Wie würden Sie den Prozessverlauf insgesamt beschreiben?

Boundary Setting

9. **Wie war das Projekt organisatorisch aufgezogen?**
    a. Waren aus Ihrer Sicht alle wichtigen Akteure vertreten?
    b. Waren es zu viele oder zu wenige?
    c. Gab es eine klare Rollen- bzw. Aufgabenverteilung?
    d. Haben sich alle für das Projekt verantwortlich gefühlt?
    e. Gab es immer wieder mal Evaluationen des aktuellen Stands?
    f. Gab es Veränderungen während des Projektverlaufs?

g. Gab es eine Vertrauensbasis zwischen den Akteur*innen?
h. Wer gab den Anstoß für das Projekt?
i. Gab es Austausch neben den eigentlichen Treffen?
j. Was nehmen Sie konkret mit? Wie haben Sie davon profitiert?
k. Waren alle konstant dabei?

Ende

10. Was würde Sie heute anders machen?

11. Welche Lehren können (andere Projekte) aus Ihrem Projekt ziehen?

12. Gibt es noch Aspekte, die Ihnen wichtig sind?
13. Würden Sie nochmal mitmachen?
14. Können Sie mir weitere Akteure aus Ihrem Projekt für Interviews empfehlen (falls nötig)
15. Danke.

III: INFORMED CONSENT FORM INTERVIEWS

Informationsblatt | April 2020
David Kuhn | Masterarbeit
Thema: Erfolgsfaktoren bei transdisziplinären Projekten

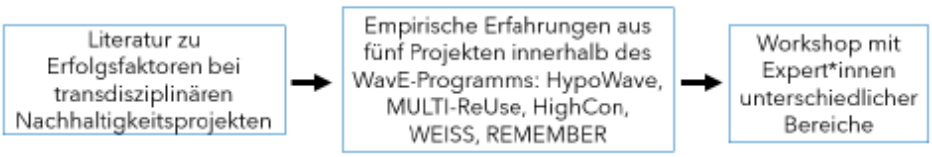
Universiteit Utrecht

Worum geht es in der Masterarbeit?

Angesichts komplexer Nachhaltigkeitsherausforderungen wie Klimawandel, Energiewende oder Wasserknappheit gibt es in Deutschland und weltweit immer mehr Projekte zur gemeinsamen Wissensproduktion. Akteure aus Wissenschaft und Praxis entwickeln in transdisziplinären Zusammenhängen Lösungen, die den unterschiedlichen Dimensionen des Problems gerecht werden sollen. Solche Projekte werden nun selbst zum Forschungsgegenstand, da die Verbindung unterschiedlicher Perspektiven oftmals so herausfordernd ist wie das Problem selbst. Inzwischen existiert relativ viel Wissen darüber, wie ein solcher Prozess idealerweise aussehen sollte. Jedoch haben nur wenige wissenschaftliche Arbeiten bisher versucht, empirische Erfahrungen transdisziplinärer Projekte in konkrete Erfolgsfaktoren zu übersetzen. Daher gibt es nur begrenzte Erkenntnisse darüber, was eine erfolgreiche gemeinsame Wissensproduktion ausmacht und welche möglichen Faktoren zu einer solchen führen.

Was ist das konkrete Ziel der Masterarbeit?

In meiner Masterarbeit möchte ich systematisch und empirisch Erfolgsfaktoren für Projekte zur gemeinsamen Wissensproduktion herausarbeiten. In einem ersten Schritt habe ich bereits eine Liste von möglichen Erfolgsfaktoren aus wissenschaftlicher Literatur gewonnen. Diese Liste soll nun mit Erfahrungen aus konkreten Projekten zum Thema Wasser innerhalb des WavE-Programms überprüft und präzisiert werden. In einem abschließenden Schritt schätzen Expert*innen ein, ob die gewonnenen Erkenntnisse aus den WavE-Projekten auch auf andere Nachhaltigkeitsbereiche übertragbar sind.



Warum sind Ihre Erfahrungen aus den WavE-Projekten besonders interessant?

Aus mehreren Gründen können wichtige Erkenntnisse aus den WavE-Projekten für ähnliche Prozesse auch in anderen Bereichen gewonnen werden: a) Wasser-Projekte müssen häufig viele Dimensionen berücksichtigen, da sich Wasser durch verschiedene Nutzungsmöglichkeiten, Zuständigkeiten und Verquickungen mit anderen Bereichen wie Landnutzung oder Klimawandel charakterisiert. b) In den WavE-Projekten kommen dementsprechend unterschiedliche Akteure aus Wissenschaft, Industrie, Verwaltung und anderen Bereichen zusammen. c) Die WavE-Projekte haben durch die Verortung im FONA-Programm eine grundsätzliche Ausrichtung auf nachhaltige Entwicklung.

Indem Sie Ihre Expertise mit mir teilen, kann ich im Vergleich mit anderen WavE-Projekten herausfinden, welche Faktoren bei Projekten zur gemeinsamen Wissensproduktion eher zu einem Erfolg beitragen.

Informationsblatt | April 2020
David Kuhn | Masterarbeit
Thema: Erfolgsfaktoren bei transdisziplinären Projekten

Universiteit Utrecht

Wie können Sie mir konkret weiterhelfen?

Ein ca. 45-minütiges Interview würde mir die Gelegenheit geben, Sie bezüglich Ihrer Projekt-Erfahrungen zu befragen. Dabei interessiert es mich besonders, ob Sie den Prozess und die Projektergebnisse insgesamt als positiv betrachten und welche Faktoren aus Ihrer Sicht für den möglichen Erfolg relevant waren. Ich würde das Interview gerne zwischen Ende April und Ende Mai 2020 führen. Selbstverständlich würde ich mich bezüglich eines konkreten Termins und des bevorzugten Gesprächskanals (Telefon, Skype, Teams, etc.) nach Ihnen richten.

Was passiert mit den Informationen, die Sie mir geben?

Ich werde die Interviews analysieren, Informationen vergleichen und die Erkenntnisse in meine Masterarbeit einfließen lassen. Dabei werden ich alle Personendaten und interne Projektdetails anonymisieren. Nach Abschluss meiner Arbeit werde ich sämtliche aus den Interviews gewonnene Daten löschen. Falls ich zu einem späteren Zeitpunkt meine Arbeit veröffentlichen möchte, würde ich Sie selbstverständlich vorher kontaktieren und, wenn gewünscht, auch alle Projektbeschreibungen aus der Arbeit löschen. In diesem Fall könnten die Erkenntnisse nicht mit dem WavE-Programm in Verbindung gesetzt werden.

Was haben Sie davon?

In jedem Fall würden Sie dazu beitragen, dass zukünftige transdisziplinäre Projekte von Ihrem Wissen profitieren. Gerne tausche ich mich mit Ihnen am Anfang des Interviews auch darüber aus, wie Sie konkret profitieren können. Neben der Zusendung meiner fertiggestellten Masterarbeit könnte ich beispielweise die gewonnen Erkenntnisse zu Ihrem Projekt für Sie aufarbeiten und präsentieren.

Wen können Sie bei weiteren Fragen kontaktieren?

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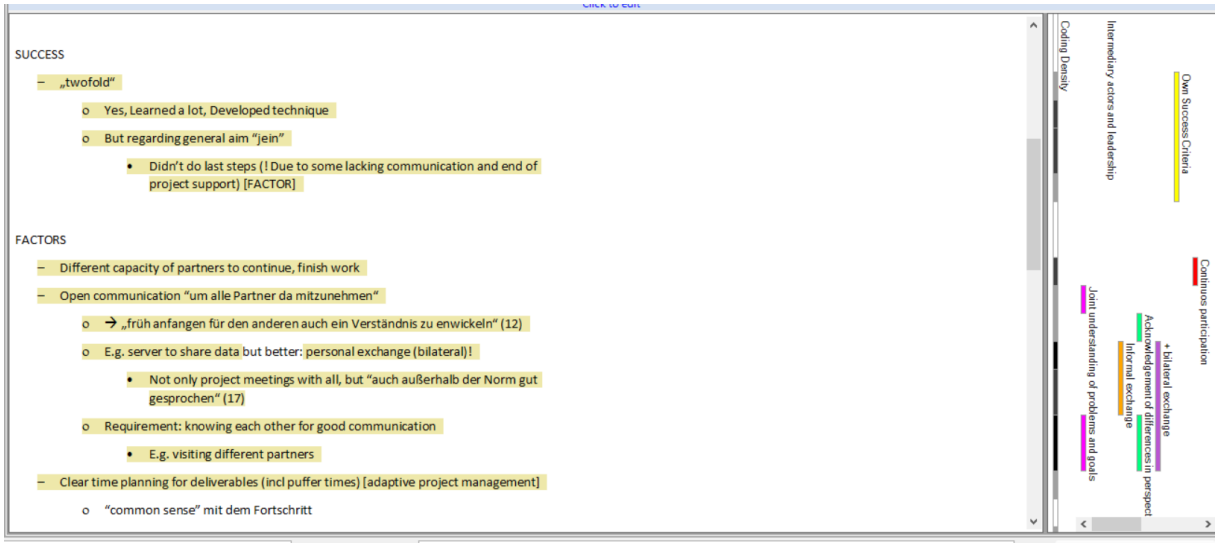
Diese Masterarbeit orientiert sich an den Forschungsleitlinien des Masterstudiengangs Sustainable Development an der Universität Utrecht. Dies schließt den ethisch einwandfreien Umgang mit der Speicherung und Weiterverwendung von aus Interviews gewonnen Daten ein. Bei Fragen oder Unsicherheiten können Sie auch Dr. Frank van Laerhoven – Mitglied des Ethik-Ausschusses der Fakultät für Geowissenschaften an der Universität Utrecht – kontaktieren: F.S.J.vanLaerhoven@uu.nl / +31 30 253 1036.

IV: EXAMPLE INTERVIEW CODING USING NVIVO

On the left: Summary of key interview statements

On the right: Codes assigned



V: INFORMED CONSENT FORM EXPERT WORKSHOP

Information sheet | May 2020
David Kuhn | Master's thesis
Topic: Successful joint knowledge production for sustainability

Universiteit Utrecht

What is the thesis about?

Facing complex sustainability challenges such as climate change or water scarcity, there is an increasing number of projects aiming for joint knowledge production. Scientific actors, policy makers and other partners develop solutions in transdisciplinary environments that seek to include the different dimensions of the respective problem. Now, such projects themselves become an object of research as bringing together different perspectives is often as complex as the actual problem. So far, there is a lot of scientific work done on the ideal design and process of joint knowledge production attempts. However, only few scholars translated different experiences of such projects into a systematic and coherent list of success factors. Thus, there is limited knowledge on what successful joint knowledge looks like and which factors facilitate this.

What is the goal of the master's thesis?

In my master's thesis, I want to systematically and empirically develop success factors for projects aiming for joint knowledge production. In a first step I built up a list of such factors based on relevant literature. Currently, I am testing this list with experiences from five projects on water reuse in Germany in which different actors participate[1]. With this, I want to confirm, reject or specify and potentially extend the factors suggested by literature. The third and last step aims for assessing the transferability of the experiences from the German water projects to other areas.

Why is your expertise helpful?

Having worked in and/or having done research about sustainability projects with a variety of actors for many years, your expertise will help me to assess the transferability of the factors developed in step 2 to other problem fields and geographical areas. With your support, I can better distinguish which of the success factors are rather specific to joint knowledge production in Germany and/or on the field of water management and which are also relevant for projects on e.g. energy in the Netherlands or climate adaptation in Bangladesh.

[1] The projects are named *MULTI-ReUse*, *HypoWave*, *HighCon*, *REMEMBER* and *WEISS*. All projects are embedded in the so-called *WavE-program*: https://www.bmbf-wave.de/en/index.php

Information sheet | May 2020
David Kuhn | Master's thesis
Topic: Successful joint knowledge production for sustainability

Universiteit Utrecht

How can you benefit?

In a 1h-workshop, we will exchange ideas on the success of joint knowledge production and its success factors. Being involved in joint knowledge production yourself, the results of the workshop might also be valuable for your work. For that, I can prepare the output of our meeting specifically for your purpose. Also, I will of course send you a copy of my thesis once finished.

How can you support me?

The workshop with you and several other experts would give me the opportunity to discuss my results. To ensure a smooth discussion, I will send you beforehand a video of ca. 10 minutes in which I present my findings so far as well as the preliminary list of success factors in a 1-page document. Depending on the availability of the invited participants, the workshop will take place on the 30th June or 2nd July 2020. Due to the corona-crisis and to ensure participation of non-Utrecht-based experts, the workshop will take place online using an interface to which all participants have access (e.g. Microsoft Teams).

What happens with the information you provide me?

With your consent, I would like to record the workshop discussion in order to analyse it afterwards in detail. I will include the findings in my thesis but of course without mentioning any personal information of you. After finishing my thesis I will delete the recordings. If I seek to publish my work at a later stage, I would contact you beforehand to ask for your permission.

Who can you contact with further questions?

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Supervisor
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Copernicus Institute for
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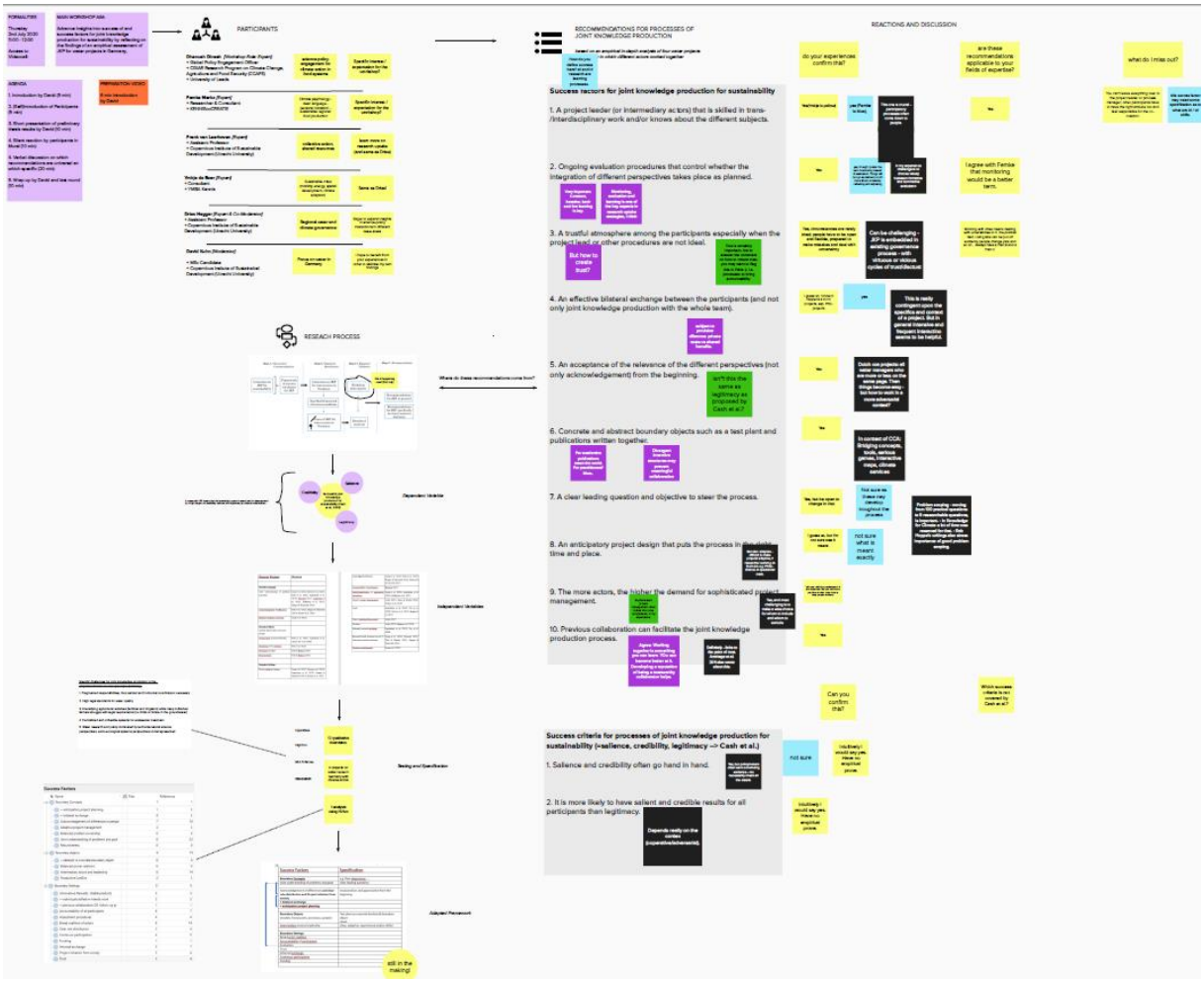
Utrecht Unversity, Netherlands
d.l.t.hegger@uu.nl

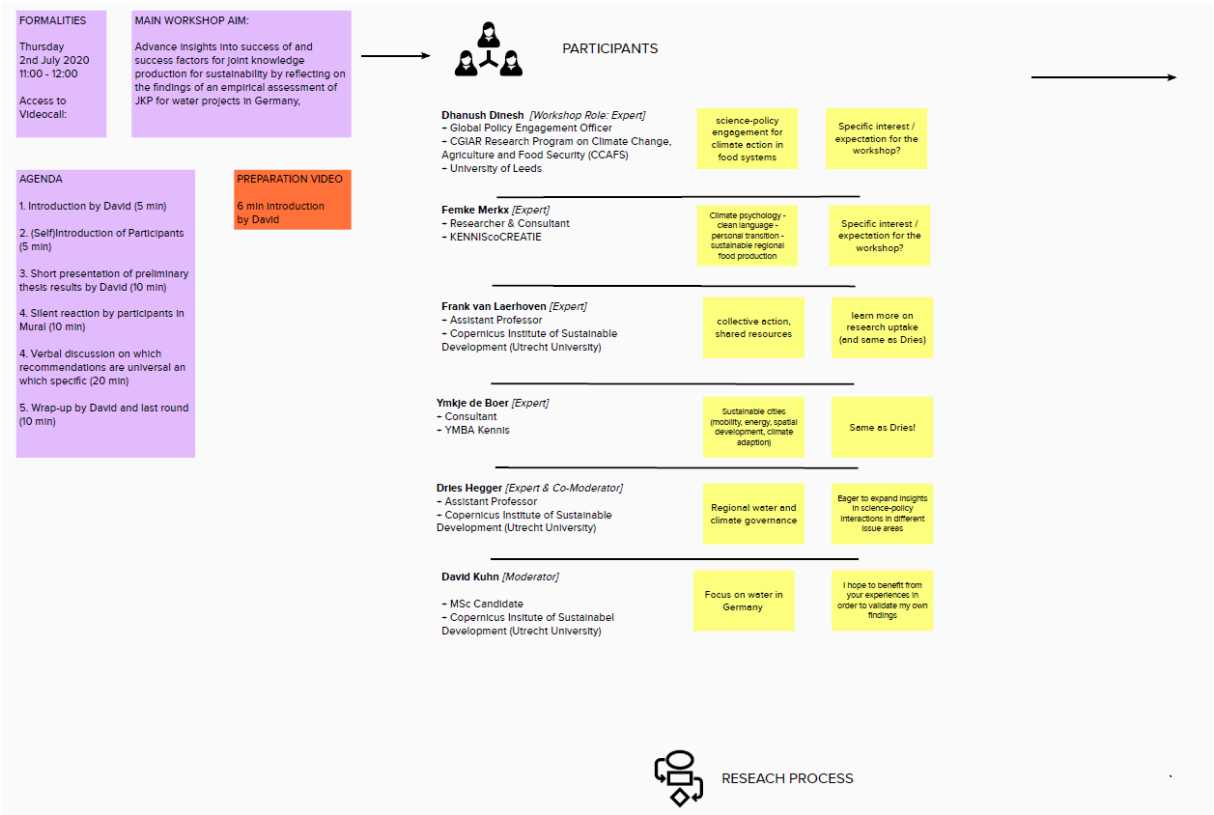
This thesis is led by the guidelines on conducting research from the Copernicus Institute of Sustainable Development of Utrecht University. This includes the ethical treatment of information gained in interviews and workshops. If you have any doubts or questions, feel free to contact Dr. Frank van Laerhoven, member of the Ethics Review Committee (Faculty of Geosciences): F.S.J.vanLaerhoven@uu.nl / +31 30 253 1036.

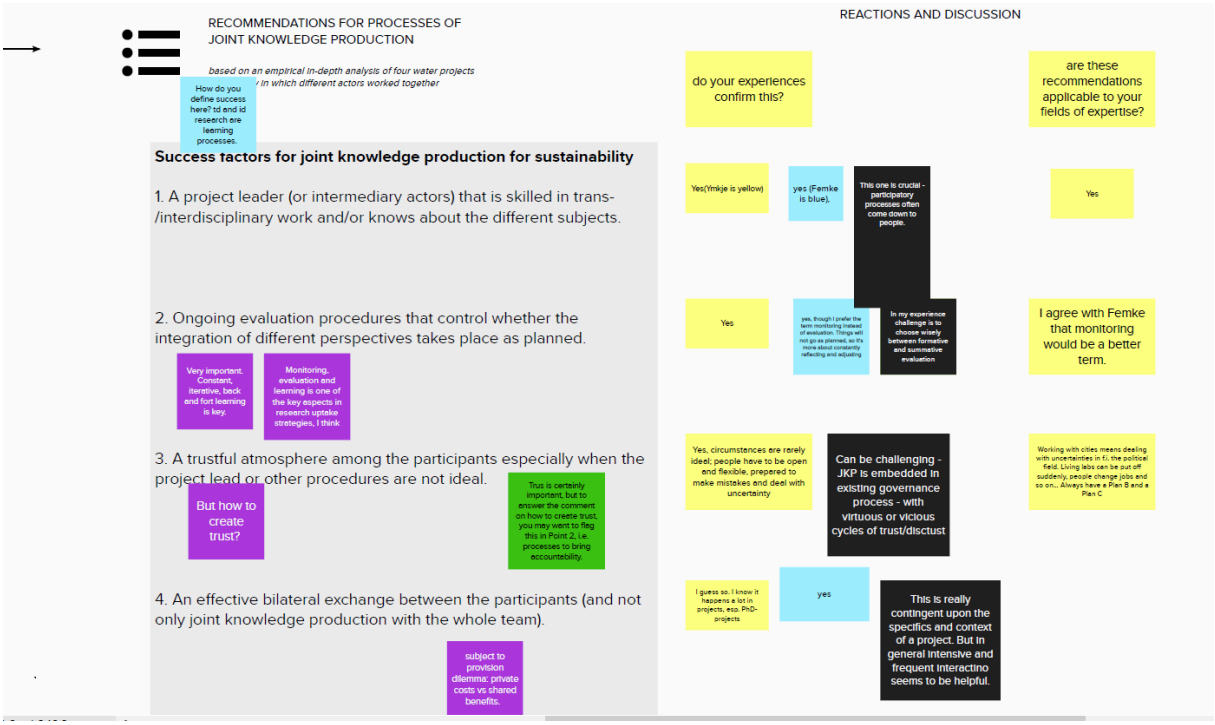
VI: MURAL EXPERT WORKSHOP[21]

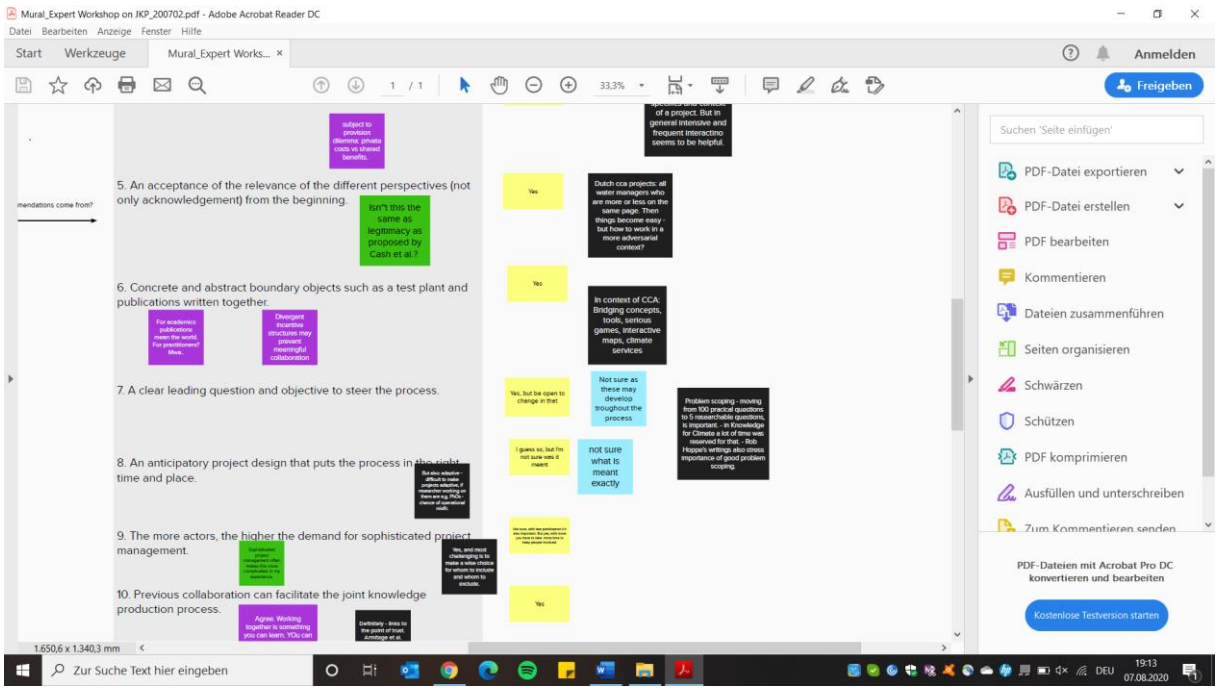


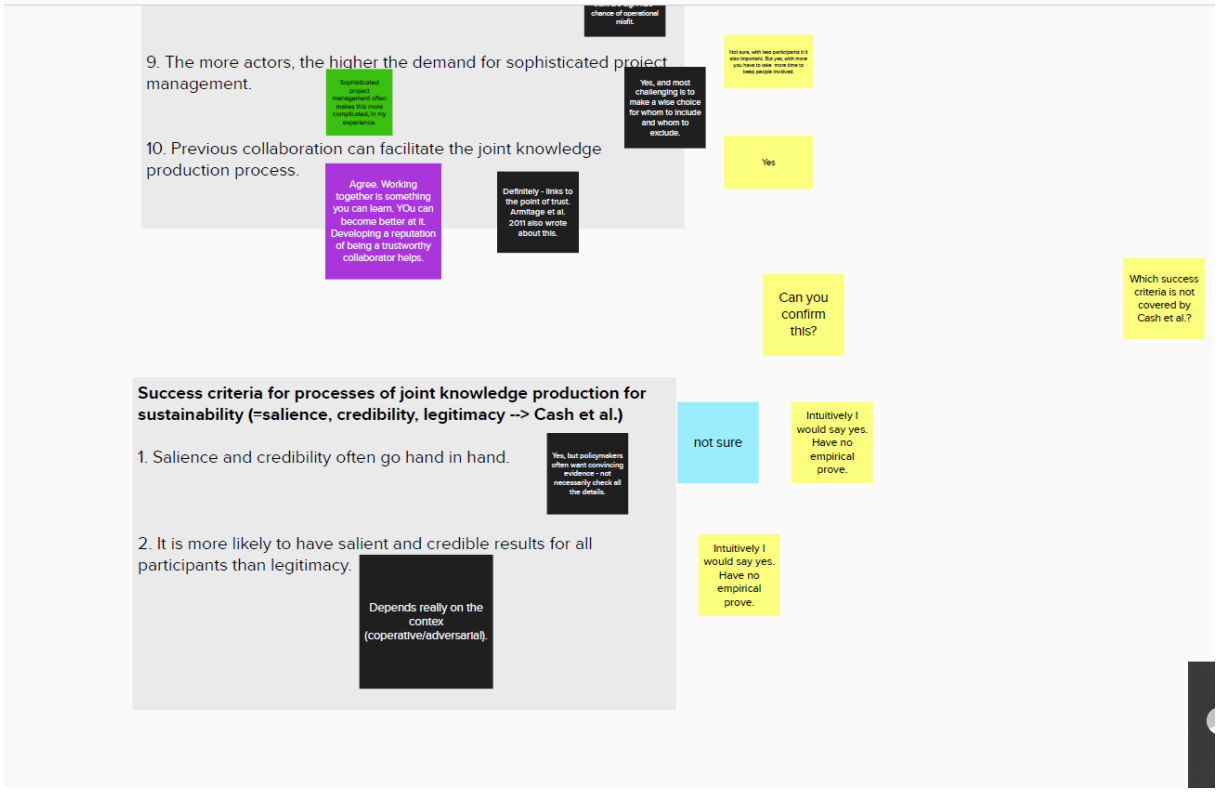
[21] Mural is a digital whiteboard tool that facilitates online discussions.

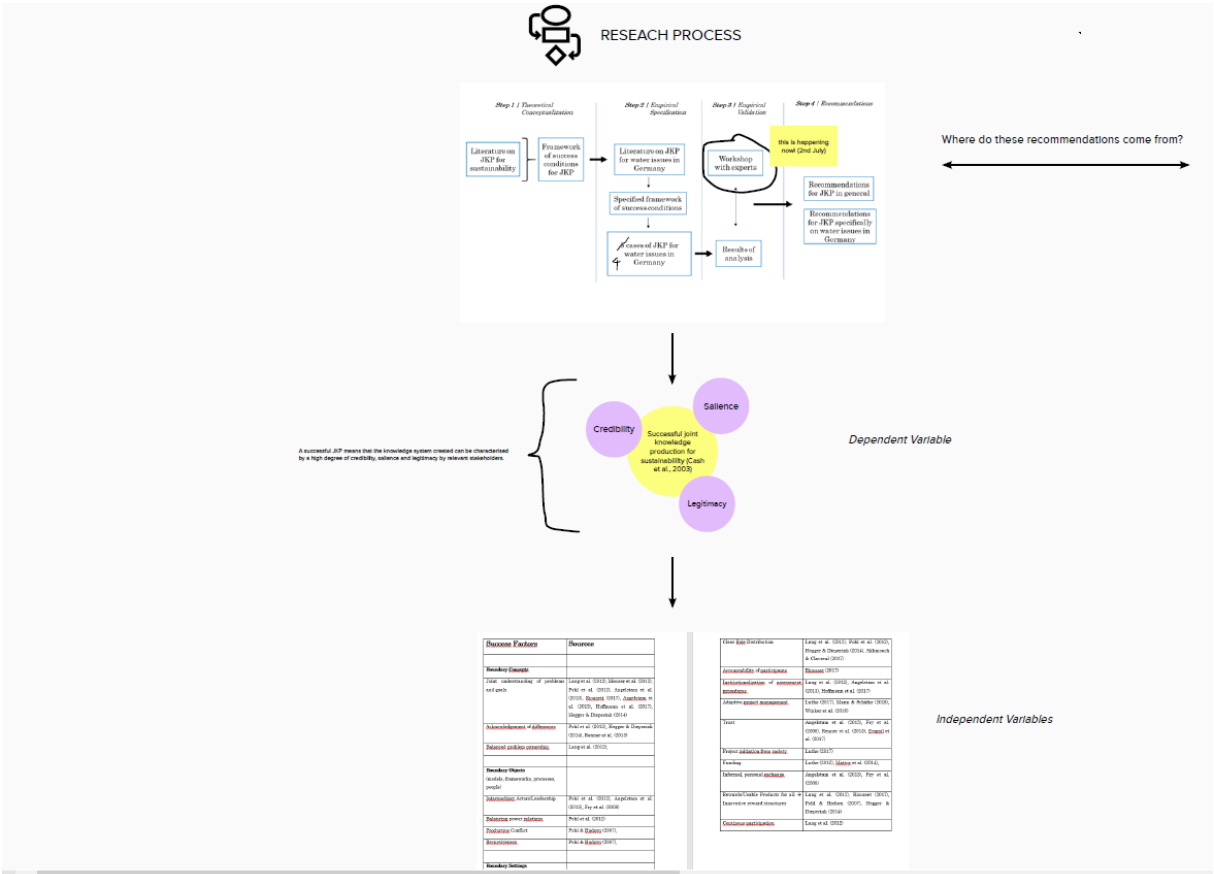
Cut into parts for readability:

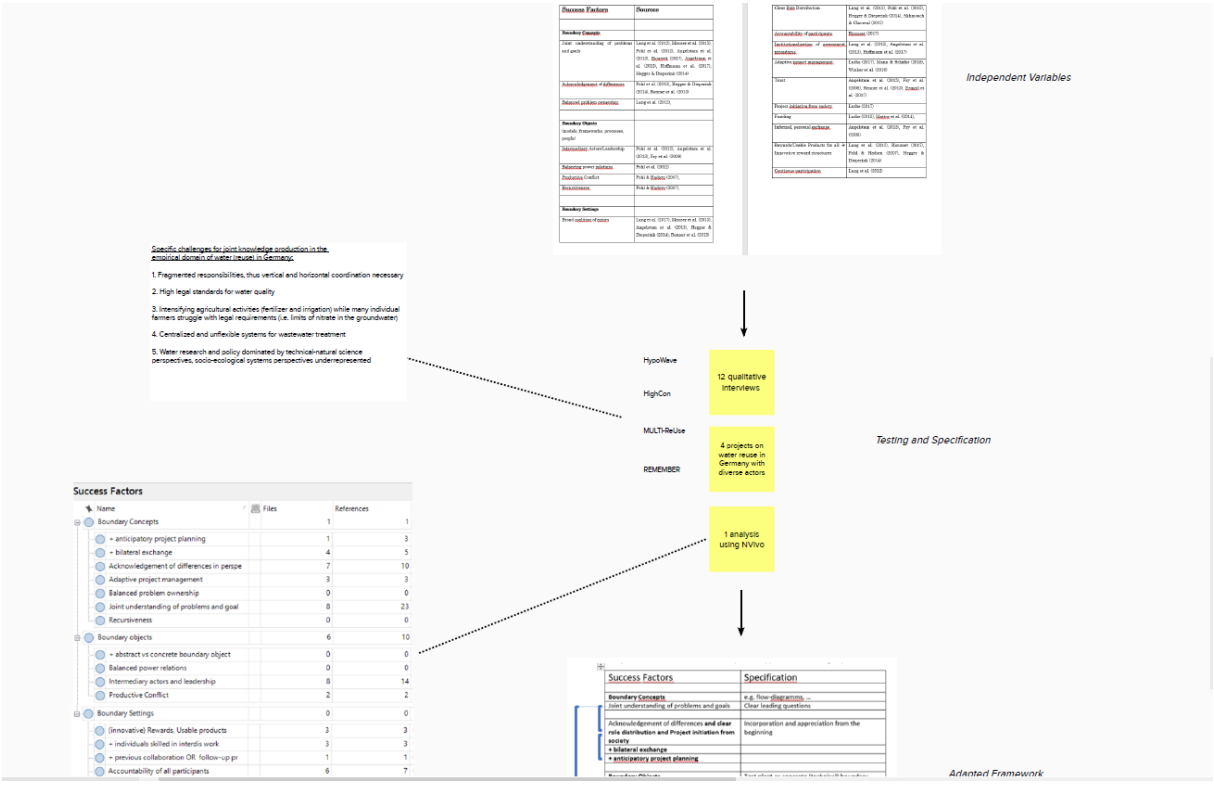


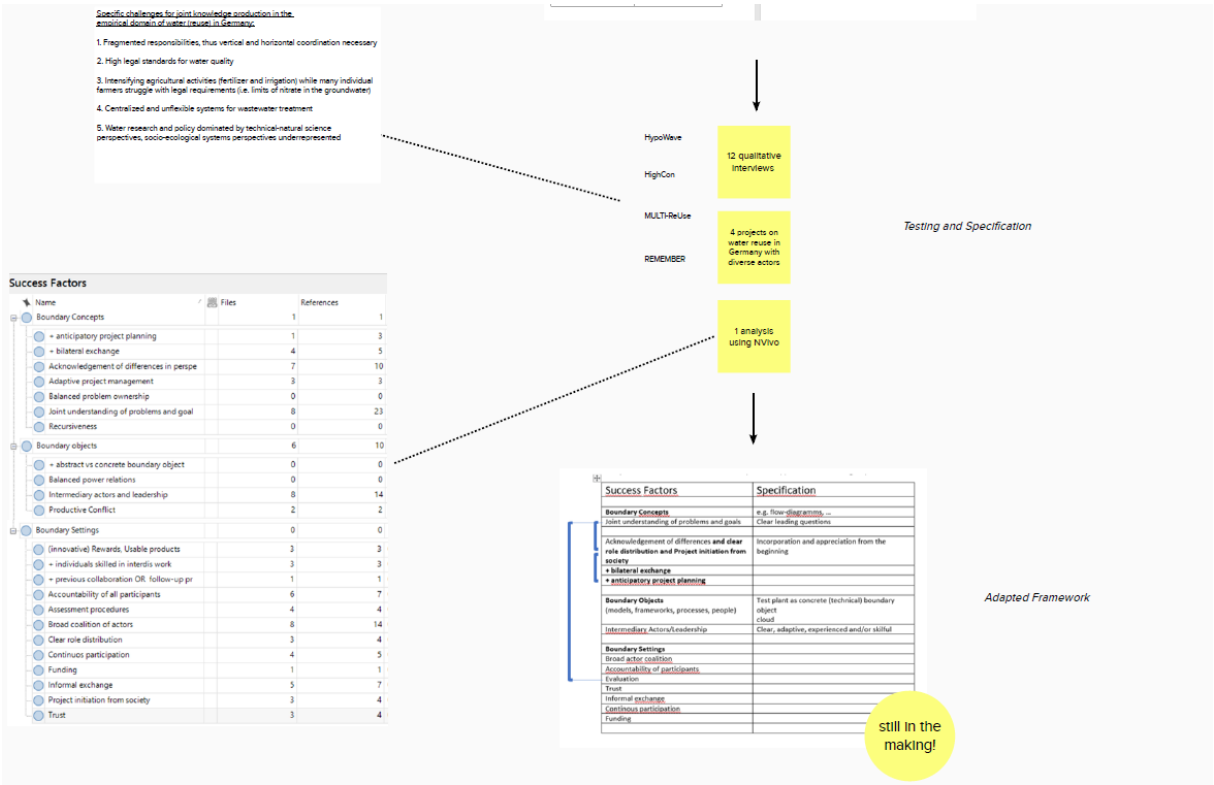



Mural_Expert Workshop on JKP_200702.pdf - Adobe Acrobat Reader DC
Datei Bearbeiten Anzeige Fenster Hilfe
Start Werkzeuge Mural_Expert Works...
Anmelden
Freigeben
5. An acceptance of the relevance of the different perspectives (not only acknowledgement) from the beginning.
6. Concrete and abstract boundary objects such as a test plant and publications written together.
7. A clear leading question and objective to steer the process.
8. An anticipatory project design that puts the process in the right time and place.
9. The more actors, the higher the demand for sophisticated project management.
10. Previous collaboration can facilitate the joint knowledge production process.
isn't this the same as legitimacy as proposed by Cash et al.?
not sure what is meant exactly
In context of CCA: Bridging concepts, tools, serious games, interactive maps, climate services
PDF-Datei exportieren
PDF-Datei erstellen
PDF bearbeiten
Kommentieren
Dateien zusammenführen
Seiten organisieren
Schwärzen
Schützen
PDF komprimieren
Ausfüllen und unterschreiben
PDF-Dateien mit Acrobat Pro DC konvertieren und bearbeiten
Kostenlose Testversion starten
Zur Suche Text hier eingeben
07.08.2020


9. The more actors, the higher the demand for sophisticated project management.
10. Previous collaboration can facilitate the joint knowledge production process.
Agree. Working together is something you can learn. YOu can become better at it. Developing a reputation of being a trustworthy collaborator helps.
Definitely - links to the point of trust. Armitage et al. 2011 also wrote about this.
Yes, and most challenging is to make a wise choice for whom to include and whom to exclude.
Yes
Can you confirm this?
Which success criteria is not covered by Cash et al.?
Success criteria for processes of joint knowledge production for sustainability (=salience, credibility, legitimacy --> Cash et al.)
1. Salience and credibility often go hand in hand.
Yes, but policymakers often want convincing evidence - not necessarily check all the details.
not sure
Intuitively I would say yes. Have no empirical prove.
2. It is more likely to have salient and credible results for all participants than legitimacy.
Depends really on the contex (coperative/adversarial).
Intuitively I would say yes. Have no empirical prove.


RESEACH PROCESS
Step 1 / Theoretical Conceptualization
Step 2 / Empirical Specification
Step 3 / Empirical Validation
Step 4 / Recommendations
Literature on JKP for sustainability
Framework of success conditions for JKP
Literature on JKP for water issues in Germany
Specified framework of success conditions
Cases of JKP for water issues in Germany
Workshop with experts
this is happening now! (2nd July)
Results of analysis
Recommendations for JKP in general
Recommendations for JKP specifically on water issues in Germany
Where do these recommendations come from?
A successful JKP means that the knowledge system created can be characterised by a high degree of credibility, salience and legitimacy by relevant stakeholders.
Credibility
Salience
Legitimacy
Successful joint knowledge production for sustainability (Cash et al., 2003)
Dependent Variable
Success Factors
Sources
Independent Variables


Success Factors
Sources
Independent Variables
Specific challenges for joint knowledge production in the empirical domain of water reuse in Germany:
1. Fragmented responsibilities, thus vertical and horizontal coordination necessary
2. High legal standards for water quality
3. Intensifying agricultural activities (fertilizer and irrigation) while many individual farmers struggle with legal requirements (i.e. limits of nitrate in the groundwater)
4. Centralized and unflexible systems for wastewater treatment
5. Water research and policy dominated by technical-natural science perspectives, socio-ecological systems perspectives underrepresented
HypoWave
HighCon
MULTI-ReUse
REMEMBER
12 qualitative interviews
4 projects on water reuse in Germany with diverse actors
Testing and Specification
Success Factors
Name
Files
References
Boundary Concepts
+ anticipatory project planning
+ bilateral exchange
Acknowledgement of differences in perspe
Adaptive project management
Balanced problem ownership
Joint understanding of problems and goal
Recursiveness
Boundary objects
+ abstract vs concrete boundary object
Balanced power relations
Intermediary actors and leadership
Productive Conflict
Boundary Settings
(innovative) Rewards, Usable products
+ individuals skilled in interdis work
+ previous collaboration OR follow-up pr
Accountability of all participants
1 analysis using NVivo
Success Factors
Specification
Boundary Concepts
Joint understanding of problems and goals
e.g. flow-diagramms, ...
Clear leading questions
Acknowledgement of differences and clear role distribution and Project initiation from society
+ bilateral exchange
+ anticipatory project planning
Incorporation and appreciation from the beginning
Adapted Framework


Specific challenges for joint knowledge production in the empirical domain of water (reuse) in Germany:
1. Fragmented responsibilities, thus vertical and horizontal coordination necessary
2. High legal standards for water quality
3. Intensifying agricultural activities (fertilizer and irrigation) while many individual farmers struggle with legal requirements (i.e. limits of nitrate in the groundwater)
4. Centralized and unflexible systems for wastewater treatment
5. Water research and policy dominated by technical-natural science perspectives, socio-ecological systems perspectives underrepresented
HypoWave
HighCon
MULTI-ReUse
REMEMBER
12 qualitative interviews
4 projects on water reuse in Germany with diverse actors
Testing and Specification
1 analysis using NVivo
Success Factors
Name
Files
References
Boundary Concepts 1 1
+ anticipatory project planning 1 3
+ bilateral exchange 4 5
Acknowledgement of differences in perspe 7 10
Adaptive project management 3 3
Balanced problem ownership 0 0
Joint understanding of problems and goal 8 23
Recursiveness 0 0
Boundary objects 6 10
+ abstract vs concrete boundary object 0 0
Balanced power relations 0 0
Intermediary actors and leadership 8 14
Productive Conflict 2 2
Boundary Settings 0 0
(innovative) Rewards, Usable products 3 3
+ individuals skilled in interdis work 3 3
+ previous collaboration OR follow-up pr 1 1
Accountability of all participants 6 7
Assessment procedures 4 4
Broad coalition of actors 8 14
Clear role distribution 3 4
Continuous participation 4 5
Funding 1 1
Informal exchange 5 7
Project initiation from society 3 4
Trust 3 4
Success Factors
Specification
Boundary Concepts
e.g. flow-diagramms, ...
Joint understanding of problems and goals
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+ bilateral exchange
+ anticipatory project planning
Boundary Objects (models, frameworks, processes, people)
Test plant as concrete (technical) boundary object
cloud
Intermediary Actors/Leadership
Clear, adaptive, experienced and/or skilful
Boundary Settings
Broad actor coalition
Accountability of participants
Evaluation
Trust
Informal exchange
Continous participation
Funding
still in the making!
Adapted Framework