Uptake of peatland ecosystem service knowledge for decision-making

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For peat sake

Abstract

Severe and ongoing loss of biodiversity and changing climate present major threats to nature and society. This requires urgent action at the science-policy interface. However, progress towards achieving international biodiversity and climate targets is currently insufficient. To improve the implementation of environmental governance processes, robust and up-to date evidence is needed to inform decision-making, built upon effective knowledge exchange and strong multi-stakeholder networks. However, if evidence of the need for action is so strong, the question remains – why is knowledge not taken up effectively and efficiently in decision making, and why does a strong science-policy gap remain?

In order to evaluate science-policy communication and exchange this doctoral research drew on data from two case studies around peatland ecosystem services in the UK and Germany and a questionnaire with international policy makers. Peatlands were chosen due to their global importance to combatting climate change and halting biodiversity loss. Data was collected using a mixed-method approach and analysed via Bayesian network analysis, social network analysis and analyses of interviews, questionnaire data and stakeholder workshop discussions. The combination of quantitative and qualitative approaches enabled a triangulation of the results, providing rigorous, in-depth insights into the science-policy process in each case study.

The results showed that in order to make informed decisions, evidence needs to successfully reach the target audience, which was not always the case given the mismatches between the transfer and perceived reception of knowledge in the case study networks. However, where there was dialogue between the case study actors, this not only improved the likelihood that knowledge and evidence was taken up, it also resulted in higher probabilities that decisions were made based on the communication. If knowledge exchange occurred regularly (at least quarterly), the likelihood for evidence-informed decision-making increased. Both bilateral and group exchange led to decisions being made. Trust was found to be an important factor in stakeholder relationships, and the critical time for trust building appeared to be in the years 1-5. This includes a deliberate choice to engage with both homophilic (similar) and heterophilic (dissimilar) actors in the network, and the creation of strong ties as well as weak ties between actors, including from pre-existing network connections, from the outset and continuing throughout the project. At the beginning of the project, this can be done by centrally located actors, however, the involvement of professional knowledge brokers can help to deliberately manage and decentralise the network structure over

time, making it more stable and less vulnerable to break apart. If knowledge exchange interactions improve awareness and hence address stakeholder needs, evidence can be tailored, delivered or co-produced accordingly.

The results shed light into the broader processes of knowledge exchange in science-policy settings. Results also seem to indicate that trust is more easily formed between homophilic actors (who close in physical distance) who held central positions in the science-policy network. Ongoing network management seem to be required to build stable networks, which enable efficient knowledge exchange. This research may help multiple stakeholders to collaborate more effectively around environmental knowledge in the future, therefore moving the world closer to successfully and collectively solving environmental issues of our time.

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Chapter 1 - Introduction

1.1 Introduction

The natural world is in a crisis (IPBES, 2019). The climate is changing while biodiversity and ecosystem services are declining rapidly (IPBES, 2019). Tipping points are already reached and more are on the nearby horizon (Adam, 2013; Lenton, 2011; Selkoe et al., 2015). Urgent action is therefore needed (Van Kerkhoff and Lebel, 2006), for example via Aichi biodiversity targets (Mazor et al., 2018) under the Strategic Plan for Biodiversity 2011-2020 of the Convention of Biological Diversity (CBD)[1] and Sustainable Development Goals (SDGs, e.g. James et al., 2018). Addressing this crisis requires multi-stakeholder[2] engagement including from policy, science, industry and society, people of all ages, gender and origin (Beisheim and Simon, 2016; Fowler and Biekart, 2017). But if strong evidence exists on these issues (for example see recent syntheses by IPBES, 2019; IPCC, 2018), the question remains – why is it not taken up effectively and efficiently in policy decision-making (Tinch et al., 2016; Young et al., 2014)? Why does a strong science-policy gap remain (Cairney et al., 2016; Young et al., 2013)? Successful environmental policies rely on sound up-to-date scientific evidence, so it is of upmost importance to study the best possible pathways for this knowledge uptake to happen. Effective communication at the interface between biodiversity research and policy is necessary, to enable up to date research outcomes to inform decision-making in environmental governance[3] (Spierenburg, 2012).

Ecosystem service knowledge

This thesis explores the uptake of ecosystem service knowledge of peatlands as one important focus for addressing environmental science-policy implementation gap. Ecoystem services are chosen, as peoples' wellbeing depends on functional ecosystems (e.g. Brauman et al., 2007; IPBES, 2019). Ecosystems are increasingly recognised as natural capital assets that supply life-support services of tremendous value (IPBES, 2019; MEA, 2005; UK NEA, 2011). At times when there is

[1] CBD COP 10 Decision X/2 accessed via https://www.cbd.int/decision/cop/?id=12268 on 4 November 2019.
[2] A *stakeholder* is any person, organisation or group that is affected by or can affect a decision, action or issue (Freeman, 1984).
[3] "*Environmental governance* is synonymous with interventions aiming at changes in environment-related incentives, knowledge, institutions, decision making, and behaviors." (Lemos and Agrawal, 2006, p. 298)

ever increasing human pressure on these ecosystems, it is necessary to take a step further and use knowledge on ecosystem services in decision-making processes (Daily and Matson, 2008). In fact the ecosystem service framework has gained momentum and increasing recognition in the policy world since the publication of the Millennium Ecosystem Assessment in 2005. According to the Millennium Ecosystem Assessment (2005) four different categories of ecosystem services can be distinguished: 1. Supporting services (services that are fundamental for all other services, such as soil production, the nutrient cycles and the protection of genetic diversity); 2. Provisioning services (e.g. provision of food, water, building material, hydropower, pharmaceutical); 3. Regulating services (regulation of climate, flooding, diseases, water quality, waste and pollination); as well as 4. Cultural services (e.g. recreation in nature, eco-tourism, aesthetic experiences, and spiritual enrichment). Research on ecosystem services has increased rapidly over the past years. One focus is on ecosystem service evaluation, especially monetary assessments (e.g. Constanza et al., 1997; Daily et al., 2000). Other research has assessed the status of biodiversity and ecosystem services in regional and global reports (IPBES 2018b,c,d,e; IPBES, 2019) and policy tools such as payment for ecosystem services (PES) (Wunder, 2015).

The ecosystem service framework has also attracted critique. Besides others Schröter et al. (2014) have synthesized this critique and counter-arguments, ranging from – it being anthropocentric rather than biocentric (Jax et al., 2013) to some arguing that it promotes the economic valuation of nature, whereas others emphasise that many ecosystem services are not connected to market-based instruments. Kenter et al. (2015) pointed out, there are different approaches to valuing nature, which are e.g. in contrast with standard neoclassical economics. Therefore, a range of different sciences are needed – a truely interdisciplinary approach, e.g. to study potential trade-offs in protecting different ecosystem services or thresholds/tipping points (Reed et al., 2013). Despite such critiques, the ecosystem service framework is widely used in various policy circles – beyond the pure environmental policy sector, including economy, transport, health and more. The framework is driving investment in natural capital, in particular the creation of ecosystem markets, which are the focus of the two case studies in the research project.

What are peatland ecosystem services?

This PhD research focusses on peatland ecosystem services knowledge in particular. Therefore, what are these services? And what are peatlands in the first place? Why are they so important? Peatlands cover only 3% of the Earth's land surface, however they contain 30% of all global soil carbon, this is more than two times that of the world's forest biomass (Bain et al., 2011; Joosten, 2011; Parish et al., 2008). They therefore play a very important part in addressing and potentially solving todays pressing environmental issues. Peatlands are waterlogged systems. The water saturated environment slows down plant decomposition. The carbon containing plant remains are accumulated as peat with a rate of approximately 1mm a year (Bain et al., 2011). This efficient long-term carbon storage service makes them an important ecosystem that plays a key role in climate regulation. Furthermore, peatlands also provide a range of other functions and services, such as recreational and educational opportunities, income through tourism, water purification (Kimmel and Mander, 2010), water regulation, regulation of micro climate, provision of food, raw material, medical plants, storage of historic/archaeological knowledge and drinking water (Joosten and Clarke, 2002). Furthermore, peatland ecosystems host multiple rare species such as sundew (*Drosera*) (Maiz-Tome, 2016), bog frog (*Rana arvalis*) (Kuzmin et. al., 2009), or the globally threatened Aquatic Warbler (Tanneberger et al., 2009). Further peatland ecosystem services are elaborated in Chapter 4. Furthermore, peatlands and their services have a growing recognition in science and international policy of their crucial role in land based climate change mitigation, given that the world's peatlands store almost twice as much as in forests. Global commitments to peatlands protection have been made via IUCN Resolution 43 "Securing the future for global peatlands" (WCC-2016-Res-043-EN) and the United Nations Environment Assembly of the UN Environment Programme Decision UNEP/EA.4/L.19 on Conservation and Sustainable Management of Peatlands (UNEP, 2019). These are supported by the UN's Global Peatland Initiative[4], which is leading the development of the world's first Global Peatland Assessment. This initiative follows recommendations on peatland restoration and sustainable management in the IPBES Thematic Assessment on Land Degradation and Restoration (2018a) and UNCCD Global Land Outlook (2017). Furthermore, national commitments to safeguarding peatlands have been made in many countries, such as the UK's Peatland Strategy (2018) and accompanying country strategies, and many countries are using peatland restoration as part of their strategy for reaching nationally determined contributions under the Paris agreement. Indonesia for example includes peatland restoration as one of four mitigation actions to reach its target of 29% reduction in GHG emissions by 2030 (Wijaya et al., 2017). However knowledge and implementation gaps regarding strong peatland policies still exists. For example the total distribution and status in regard of degradation of peatlands leaves many knowledge gaps (e.g. Tanneberger et al., 2017). Huge worldwide mapping and monitoring projects using modern remote sensing and modelling technologies for example by the Global Peatland Initiative and its national partners are ongoing.

[4] https://www.globalpeatlands.org/ accessed on 23 May 2019.

Yet the currently known distribution and status and any other relevant peatland knowledge need to reach policy and other decision makers (Joosten et al., 2016). Scientific evidence is clear about the fact that peatlands need to be wet in order to fulfil their ecosystem services and function. Peatlands that actually form peat are called mires (Joosten et al., 2017). Many argue that these evidences successfully need to reach decision-makers as their awareness is of immense importance in order to implement sustainable action into policy for the protection of these relevant ecosystems worldwide. However this evidence is for example only very limited included in the current European Common agriculture policy. Great ongoing effort is put in to ensure the inclusion of current knowledge on peatland ecosystem services in international Kyoto follow up policy agreements (e.g. by the Greifswald Mire Centre and the IUCN Peatland program; Joosten et al., 2016). These in turn need to be implemented and enforced in national legislation. A huge interdisciplinary approach is need, whereas the main knowledge/implementation gap is in the lack of social science on peatlands. This particular the case with an emphasis on the operation of ecosystem service markets in practice cases studies.

This thesis highlights two case studies: the Peatland Code[5] in the United Kingdom and the MoorFutures project[6] in Germany. Both were chosen as they deal with ecosystem services of peatlands. Both peatland initiatives were developed to address the need to find alternative funding for peatland restoration, to ensure that peatlands can indeed play their important role in addressing biodiversity loss and especially in combating climate change. Regional carbon markets, or so-called payment for ecosystem service schemes were established in order to do so. Multi-stakeholders are involved and including experts from the natural and social sciences, policy and land management practitioner communities, and business and carbon market consultants (Bonn et al., 2014). For further details on the case studies see section 3.2.

1.2 Barriers for efficient knowledge uptake and known reasons for an implementation gap

Identified barriers to getting environmental knowledge and evidence into environmental governance exist and include: still widespread linear models of communication; unknown relative

[5] http://www.iucn-uk-peatlandprogramme.org/peatland-code accessed on 18 March 2019.
[6] http://www.moorfutures.de/ accessed on 18 March 2019.

importance of identified factors influencing knowledge exchange and decision-making; non-existing and/or inefficient network structures linking diverse actors at the science-policy interface and missing actors (e.g. knowledge brokers[7] and bridging organisations[8]) to develop and manage the last point; and the lack of knowledge on the policy-makers' perspective in successful knowledge exchange (Bodin, 2017; Durant et al., 2017; McNie, 2007; Reed and Meagher, 2019). Moreover, there is a lack of precision on the right timing, format and language of the transfer and delivery of environmental and ecosystem service knowledge.

Decision-makers often rely on their own personal experience, knowledge from known trusted sources and secondary sources of information such as websites for developing and adapting environmental policies (Metzger et al., 2010). In contrast with multiple authors, who equal decision-makers to policy decision-makers, all of the actors that are included in the case studies in this thesis (chapter 4, 5 and 6) are defined as decision-makers regardless of their profession. Although some were policy-makers, others were not members of the policy community, but instead were part of the policy networks linked to the two case study initiatives (see Heclo and King (1978) for a definition of a policy network). This inclusion derives from the following definition: "Decision making is one of the basic cognitive processes of human behaviors by which a preferred option or a course of actions is chosen from among a set of alternatives based on certain criteria." (Wang and Ruhe (2007, p. 1). Decisions can occur every few seconds, either consciously or subconsciously. Decision-making can be categorised as: intuitive, empirical (including criteria such as existing knowledge), heuristic and rational. This research focuses on empirical decision-making based on existing knowledge, but bears in mind that decisions can also be based on other factors including the decision-maker's norms and values. Haynes et al. (1997, p. 4) state that "evidence-based decision-making involves the explicit, conscientious and judicious consideration of the best available evidence in making decisions". However, multiple authors have found that research evidence is not taken up by decision-makers. Cvitanovic et al. (2013) state a reason for not using scientific knowledge in decision-making is that marine resource decision-makers were not aware of the existing scientific knowledge, which led them to base their decisions on individual experiences or other secondary sources of information (Cvitanovic et al., 2014).

[7] Knowledge brokers in this thesis are people who facilitate interactions between stakeholders relevant at the science-policy interface. See more under 2.3.3 below.

[8] Bridging organisations can be departments located in both the academic as well as policy worlds. Also multiple NGOs, companies, public(s), industry, media any others can function as bridging organisation. Some of these might be located or positioned closer to science or to policy or neither and try to remain independent, but all aim to liase between the scientific and the political spheres. See more under 2.3.3.

More specifically, referring to decision-making in a peatland context, Sutherland et al. (2004) found that 77% of wetland managers' management decisions were based on anecdotal and personal experiences and only 2% were based on peer-review scientific evidence. Also other authors have found that scientific evidence only seems to play a minor role for most policy decisions (Cook et al., 2010; Walsh et al., 2015). And while evidence use in the medical research sector seems far advanced compared to the use of scientific evidence for environmental decision-making, Stewart et al. (under review) that yet another reason for not taking up evidence is the lack of using open science practices, open data policies and standardisation of methodologies, as this lead to non-comparable studies and up to 85% of so called "research waste" in medical research alone (Glasziou and Chalmers, (2018). An implementation gap between scientific evidence and its application in policies exists (Kirchhoff et al., 2013; Knight et al., 2008; Sutherland et al., 2004). In order to improve the uptake of scientific knowledge into environment policy decision processes it is critical to examine barriers for successful knowledge uptake. Hence an aim of this research is to study the exchange of scientific knowledge about ecosystem services in relation to actual decision-making based on this knowledge that has been exchanged.

Recently the research field of knowledge exchange has emerged in environmental sciences in search for more successful mechanisms to increase the likelihood of knowledge uptake (Cvitanovic et al., 2016; Fazey et al., 2013; Phillipson et al., 2012; Reed et al., 2014). This research builds on critiques of the widespread linear model of communication (Pielke, 2007). This model assumes that scientists provide research evidence (mainly by scientific publications) and expect policy makers to then come to well informed decisions (Pielke, 2007). Indeed some global assessments, such as the Global Biodiversity Assessment (UNEP, 1995), have had limited policy impact[9] because they applied this communication model (Watson, 2005; Young et al., 2014). Also the Intergovernmental Panel on Climate Change (IPCC) lost public trust and credibility in the event called 'climategate' as they applied the linear model according to an article by Beck (2011). This leads to an implementation gap, with an emphasis on knowledge transfer (one-way communication, which "pushes" from the knowledge producer to the users of research) rather than two-way knowledge exchange built on trusting relationships. The latter requires stronger interaction between researchers, decision makers and further stakeholders (Lavis et al., 2003). Therefore, a two-way dialogue between researchers and policy makers might be more suited to

[9] Research *impact* can be defined as "perceived and/or demonstrable benefits to individuals, groups, organisations and society (including human and non-human entities in the present and future) that could not have been possible without new knowledge arising from research" (Reed et al., 2020).

find solutions to safeguard the environment (Koetz et al., 2011; Young et al., 2014). The purpose of knowledge exchange is the increased likelihood that research evidence and knowledge will be used in policy decisions. The implementation and uptake of scientific knowledge into policy decision making seems so far inefficient (Weichselgartner and Kasperson, 2010). Hence there is a strong emphasises on the need for two-way dialogue interactions between all stakeholders involved, especially researchers and policy-makers (Cornell et al., 2013; Roux et al., 2006; Van Kerkhoff and Lebel, 2006). Knowledge exchange has previously been studied in a range of fields, such as the health sciences (Graham et al., 2006), marine sciences (Cvitanovic et al., 2015) and political sciences (Boaz et al., 2019; Nutley et al., 2010). Although, operating in very different disciplinary contexts, research studies collectively emphasise the importance of the quality of social networks connections for the success and impact of the knowledge exchange amongst participants. However, research on the role of knowledge exchange in environmental policy is less well established and there is little engagement between the various research fields exploring these issues (Fazey et al., 2013).

Given that some ecosystem services can create trade-offs (e.g. services such as the revision of peat versus services like flood protection by functional peatland ecosystems) multiple actors using and competing for them (Bodin and Crona, 2009) there is a need to include stakeholders with conflicting objectives, norms, value and various different knowledges alongside research evidence in environmental governance (Ostrom, 2000). This needs to include, for example, local and indigenous knowledge, scientific and political knowledge across a range of disciplines in the co-production[10] of governance solutions with those who manage the natural environment (Raymond et al., 2010). Within a science-policy interface project setting the involvement of all relevant stakeholders is necessary from the start and often requires the use of a communication expert to facilitate and mediate through the projects duration. However, current modes of research and decision-making often act as a barrier to this. Researchers have a tendency to believe their job is done once they have published their findings in peer-reviewed journals, rather than actively filling the "knowing-doing gap" (Knight et al., 2008). Rather than focussing on one-way communication

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[10] *Knowledge co-production* refers to the active involvement and engagement of multiple actors in the production of knowledge from various sources in order to find solutions for complex governance problems, in this case of this thesis, solutions to pressing environmental issues on peatland ecosystems and their services, through an facilitated and designed process (e.g. Frantzeskaki and Kabisch, 2016; Voorberg et al., 2014).

of research to specialist audiences, research evidence needs to evolve through multi-party dialogue (Bielak, 2008).

A range of factors for knowledge exchange are therefore known, but yet their relative importance for improved decision-making (over time) remains unclear. This results in persisting temporal mismatches between research and policy cycles and the time-horizons over which each require evidence. There is a gap in the literature regarding the actually best timing to merge the different time tables. In reality research is often only communicated at the end of a research project and often only passively and/or indirectly to policy makers. Is this indeed the best timing the present research results? There is evidence that research shall engage with their target group, including policy makers, as early as possible in the research project cycle (Bielak, 2008; Phillipson et al., 2012). This can either happen in times of stability (Olsson et al., 2004) or if so called windows of opportunities arise (Meijerink, 2005; Nohrstedt, 2005). There is wide consensus that there shall be an "ongoing", "frequent", regular" exchange between relevant actors (e.g. Cvitanovic et al., 2018; Durham et al., 2014; Edelenbos and Klijn, 2007; Young et al., 2013). However, it is currently unclear from the existing published knowledge at what point of the relationship decisions are made and when trust is formed[11]. This research aims to address the need to isolate and analyse key factors for knowledge exchange as it is important for informing practice so that those responsible for research uptake into policy can focus their limited resources on the factors that matter most.

Current knowledge has already elaborated that global environmental problems can only be solved with engagement of multiple and often diverse stakeholder groups (Fazey et al., 2014) as mentioned before. Yet these actors are often not connected, resulting in missing network structure disabling knowledge exchange and hence knowledge uptake for decision-making. If network connections do exist they seem inefficient to ensure successful knowledge uptake. Failures in implementing ecosystem service knowledge into environmental governance might be caused by institutional and spatial mismatches (Koetz et al., 2011). For example, governing multi-level ecosystem services requires stakeholders to operate at multiple inter-locking scales whereas protection of localised ecosystem services would be poorly fitted in a pure international institution setting (Cash et al., 2006). Furthermore, implementation gaps might be due to centralised

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[11] *Interpersonal trust* can be developed between individuals and include a willingness to accept risk or be vulnerable in the relationship (Mayer et al., 1995; Stern and Coleman, 2015).

hierarchical and therefore undynamic power structures. Another reason for inefficient knowledge exchange is due to network connections which are mainly built on homophilic connections, where interacting individuals are similar in their characteristics as well as physical location (McPherson et al., 2001; Rogers, 2003). Missing heterophilic actors, communicating individuals who are very different in their characteristics, present the multiplicity and diversity of opinion, values, belief and hence ideas necessary to find solutions to environmental problems. This is underpinned by various models and theories including the Values, Beliefs and Norms theory. This suggests that individual behaviours are driven by personal norms (e.g. the individual feels obliged to do or not to do something in order to avoid negative consequences) and personal values (e.g. altruistic versus egoistic values). This influences beliefs, including environmental beliefs (Stern, 2000). Furthermore, the social dilemma system model suggests that social dilemmas can occur when groups, individuals or actions based on self-interest come into conflict with those based on more altruistic, community or environmental interests. This may lead to the adoption of strategies based on varying degrees of co-operation that have the potential to transform behaviours and pro or contra environmental outcomes (Gifford, 2008). This overlaps with Social practice theory, when applied to pro-environmental behaviour, suggests that behaviour change is a complex social process that can only be understood and influenced socially e.g. via multi-stakeholder processes (Hargreaves, 2010).

In order for such diverse believing and behaving actors to be successfully integrated into environmental governance network structures, more evidence is needed on how this can be achieved. In order to ensure that they are able to use their full potential such multi-stakeholder engagement activities need to be well facilitated. Furthermore, the network might need to be deliberately managed to develop and maintain the missing or inefficient network structures and enable co-production of knowledge (Bodin and Prell, 2011). Knowledge brokers and bridging organisations might be the right actors able to improve communication amongst stakeholders and to cross different scales. However, to date, only limited theoretical and empirical evidence about the value of these actors exist (e.g. Cvitanovic et al., 2017; Meyer, 2010).

A further gap in the research exist as so far few studies have focused on the perceptions of policy makers, who are mainly responsible for using evidence for their decision-making processes. Most studies on knowledge exchange have mainly focused on researchers perceptions of the impact of the evidence they collect (Chubb and Reed, 2017). Furthermore, there is limited analysis of the pathways through which this evidence reaches (or is transformed or blocked) by the involved actors (Reed et al., 2018). Whereas the mentioned barriers above are not particular focussed on peatlands, it seems very likely that they exist at the interface between science and peatland policies too, but have not been studied yet. Objectives of this PhD project address and provide guidance to study these barriers and are described below in section 1.4.

1.3 Thesis relevance

Addressing and filling research gaps and barriers as described above will be crucial for enabling effective knowledge uptake and implementation into environmental policy. Despite the documented effort to improve knowledge exchange at the science-policy interface, implementation gaps remain (e.g. Knight et al., 2008). Whereas the barriers of knowledge exchange and uptake are relatively well documented, the implementation and successful application of this knowledge is still not satisfactory to make sufficient progress towards urgent environmental action. How to upscale suggested solutions remain uncertain.

This is in part due to the complexity of policy making and governance in the environmental domain (Reed and Meagher, 2019). There are various challenges in environmental governance. This includes the highly interconnectedness of today's environmental challenges. There is a wide range of spatial and temporal scales over which environmental processes operate that environmental governance needs to cover. In fact some problems need to be addressed beyond the jurisdiction of current existing policies, for examples issues arising with the high seas, international waters beyond any national jurisdiction. The temporal scales that need to be addressed in environmental governance span from rapid response within hours, such as because of issues arising due to weather events, to the development of sustainability long-term goals that are implemented over generational time-scales. Further challenges arise due the diversity of stakeholders, all of which need to be involved to find sustainable policy solutions long-term. These might even include climate change deniers who, based on their deep-rooted beliefs, often lobby their interests from a very contrasting view point (Reed and Meagher, 2019). Ideally environmental policies need to ensure that, in the case of peatlands, their degradation is stopped and restored to tackle climate change, ensure sustainable healthy soil communities, and find alternative more sustainable ways to use such land and to enable stakeholders to adapt.

Evidence is provided to environmental policy makers from various sources including natural and social sciences, industry and also from other policy sectors. They must then interpret often contradictory information. Therefore, there is a need to synthesise and co-produce multi-disciplinary knowledge and mediate conflicts due to underlying diverse beliefs and mitigate existing trade-offs. While evidence is collected in the first place uncertainties remain and need to be addressed transparently, as this can confuse decision-makers and could therefore be neglected (Boaz et al., 2019).

Peatland governance deals with many of these challenges too. Main knowledge/implementation gaps still pertain due to the amount or even lack of social science on peatlands and case studies of the operation of ecosystem service markets. Even though peatlands are clearly allocated to national jurisdictions, the greenhouse gases emitted by degraded peatland soil have severe world-wide effects. This makes peatland ecosystems a highly relevant context in which to embed this study. The Millennium Ecosystem Assessment (2005) amongst others ascribes peatlands a very important role in the regulation of global climate change and global agreements such as the Convention on Biological Diversity (CBD), the UNFCCC and Kyoto follow-up protocols as well as the Ramsar Convention on Wetlands promote peatland restoration and protection of its ecosystems services as key contribution towards reaching biodiversity and climate targets (Joosten, 2011; IPCC, 2014).

Beside their potential benefits, peatlands are under threat. In spite of the benefits, European peatlands lost more peat than any other continent - so far over 50% of mire area has been lost due to a high population pressure and climatic conditions that is suitable for extensive agriculture practices alone (Joosten and Clarke, 2002). Globally 500,000 km^2 of drained peatlands releases around 2,000 million tons of CO_2e (Carbon dioxide equivalent) annually (Joosten, 2011). Commercial extraction, such as for horticulture and drainage of peat are main causes of peatland destruction (Chapman et al., 2003). The drainage of peatlands results in the release of the stored carbon. The land use sector emits around 25% of all global CO_2e making drained peatlands a major source of greenhouse gases emissions (Bonn et al., 2014). For example 9.5% of the UK is covered with peatland and they built the most important terrestrial carbon storage (Bain et al., 2011). However damaged UK peatlands currently release around 3.7 million tonnes CO_2e annually (Worrall et al., 2011), this is equivalent to emissions released by around 660,000 UK households (Bain et al., 2011). Due to the wide range of peatland ecosystem services that contribute to human well-being, a sustainable use of peatlands and their protection and restoration has a high priority (Kimmel and Mander, 2010). According to de Groot et al. (2010), investing in a sustainable use of nature can generate economic benefits. The values of intact wetland ecosystems in Canada for example were estimated to be around US$ 8800 per hectare compared to US$ 3700 per hectare for a conversion to intensive farming (Balmford, 2002). Balmford (2002) expressed and measured value of peatlands in monetary terms, however value can also be measured in non-monetary terms (e.g. frequency of visits to a specific peatland site) (Kenter et al., 2015). Analyses of peatland restoration literature point out that once the habitat is converted the value of the restored peatland remains lower compared to intact ecosystems (Kimmel and Mander, 2010). The value of nature and in this case – peatlands – can be expressed differently, including monetary and non-monetary approaches as mentioned above. Relational values for example express, how humans value their relationships with nature (O'Connor and Kenter, 2019). Preventing further damage and restoring healthy ecosystem functions and services of peatlands can therefore play an important role in climate regulation. Restoration of peatlands is cost-effective especially considering the trade-offs and on-going costs for society long-term (Bain et. al., 2011). In contrast, peatland fires in Scotland in May 2019 for example doubled Scotland's greenhouse gas emissions, while "only" burning for six days[12]. Peatland burning is a still widespread measure that has gain criticism[13]. There is a need for urgent action for peatland ecosystem service knowledge to be taken up and integrated into national and international peatland governance processes and policies (Crump et al., 2017). A survey of national peatland policies following the IUCN resolution 43 has pointed out that, from the minimum of 175 peatland nations worldwide (Parish et al., 2008) only 27 countries reported to have existing national policies that help to protect peatland and five further national peatland policies are known to be under development[14].

Furthermore, policies in the study system relate to local, national, regional as well as international peatlands and very importantly, environmental and climate policies. Given my focus on multi-stakeholder knowledge exchange including stakeholders from multiple sectors and disciplines this is an important background. My study system could influence policies related to EU Common Agriculture Policy, Paris agreement follow-up policies (as mentioned by one of my interviewees from the MoorFutures case study), also Scottish, Welsh, English and Northern Irish peatland policies in the devolved administrations of the UK; and Mecklenburg-Pomerania, Schleswig Holstein, Brandenburg in Germany. Also relevant is the inclusion of MoorFutures into International carbon trade systems (an expectation two of my MoorFutures interviewees pointed out) and the ability for Peatland Code projects to be verified under voluntary carbon standards (though this has not happened to date). Currently there are also immense changes in the post-Brexit agricultural policy, for example the Environmental Land Management Scheme included in

[12] https://www.bbc.com/news/uk-scotland-50435811 accessed on 8 Sep 2020.
[13] https://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/images/Review%20Impacts%20of%20Burning%20on%20Peatlands%2C%20June%202011%20Final.pdf accessed on 8 Sep 2020.
[14] https://www.iucn-uk-peatlandprogramme.org/sites/default/files/header-images/IUCN%20Resolution%2043%20summary%20report-FINAL.pdf accessed on 8 September 2020.

England's Agriculture Bill, and equivalent schemes being developed in each of the devolved administrations which are relevant to the study.

Peatland ecosystem services have been chosen as a case study subject for the above reasons. National and international peatland case studies will be used to study knowledge exchange processes. The research findings will be used to improve processes of knowledge generation and sharing by recommending best practice examples, e.g. for effective network structures. The results of my PhD research will be able to contribute to a more effective knowledge exchange amongst multiple stakeholder actors, increasing the likelihood of direct knowledge uptake into peatland conservation policies and further relevant policy sectors able to protect peatlands and their ecosystem services. The study therefore provides a valuable basis for the improvement of knowledge adoption and implementation strategies in the field of ecosystem service conservation and beyond. It will also be used to provide guidance for researchers and professional communicators more generally, about the design and practice of knowledge exchange, through the development of guidance documents and training. This will be ensured through collaboration with the International Union for the Conservation of Nature (IUCN) Peatland Programme and the UN Global Peatland Initiative.

1.4 Research aims, objectives and questions

The primary aim of this thesis is to find ways to improve evidence-informed decision-making around the protection of peatland ecosystem services. To do this the PhD advances theoretical and empirical evidence for peatland governance science-policy interface interactions about the exchange and uptake of knowledge in environmental decision making. This PhD project explores factors that influence how knowledge about peatlands and their ecosystem services is generated, shared through social networks and applied in conservation policy. It considers the role of social network structure, modes of communication, modes of learning, trust, the importance of facilitating, blocking and transforming knowledge about peatlands so it can successfully implemented into national and international policies.

In order to achieve the primary aims and advance the knowledge base associated with successful knowledge uptake into decision-making, this thesis addresses the following four objectives directly connected to the research questions:

1. Analyse the relative importance of key factors enabling knowledge uptake and evidence-informed decision-making by exploring two peatland case studies.

- What factors in the knowledge exchange process lead to decisions informed by ecosystem service knowledge?
- What is the relative importance of these factors facilitating knowledge exchange to increase the likelihood for decision-making in science-policy networks?

2. Explore the knowledge exchange network and decision-making structure in two peatland ecosystem case studies to identify and explain which structural elements facilitate the uptake and implementation of ecosystem service knowledge in peatland governance.
    - How are case study actors linked through knowledge exchange activities relating to peatlands ecosystem service knowledge?
    - What structural elements of social-ecological network systems lead to decisions informed by ecosystem service knowledge?
    - Who are the necessary network actors and what are their roles within the network?
    - Who is responsible for set-up, maintenance and facilitation the desired network structure?
    - What do successful network structures look like?

3. Analyse policy makers' perceptions of successful knowledge exchange at the peatland science-policy interface.
    - What are policy makers' perceptions of successful knowledge exchange at the science-policy interface? How and through whom does knowledge currently reach policy makers?
    - How do decision makers request and expect knowledge and evidence?
    - In which format/language/mode of communication should knowledge reach policy makers to enable increased knowledge uptake and trust building?

4. Formulate recommendations for stakeholders at the science-policy interface to exchange their knowledge successfully with the other relevant stakeholder groups, increasing the likelihood that their knowledge informs and is implemented in decision-making.

The research questions derive from an initial literature review and my experiences working as a knowledge broker at the German platform for biodiversity research[15], a project that brought together biodiversity researchers and national and international policy makers.

The aims and objectives of this thesis are addressed with a mixed-methods approach, described in Chapter 3. In summary, the research conducts an in-depth analysis of two peatland case study projects and use a combination of literature review, stakeholder interviews, stakeholder workshop discussion, Social network and Bayesian analysis. Two case studies dealing with ecosystem services of peatlands are chosen. This case study focus was chosen as effective peatland governance can play an important factor in our global climate and biodiversity protection world-wide. Therefore, the research compares findings from case study research in the UK (Peatland Code) and Germany (MoorFutures) (see detailed case study description in 3.2) to infer generalisable principles and develop new practical applicable knowledge exchange strategies to generate beneficial societal and environmental impacts. Additionally, a questionnaire aimed at international peatland policy makers sheds light into the perspective of the policy community on effective knowledge uptake and trust building.

The research aims to enrich the knowledge base on knowledge exchange for environmental governance, to improve processes of knowledge generation and sharing for peatland policy internationally. This is being ensured through collaboration with the International Union for the Conservation of Nature (IUCN) UK Peatland Programme, the Greifswald Mire Centre in Germany and the UN Global Peatland Initiative. The research findings will be used to provide evidence-based guidance for researchers about the design and practice of knowledge exchange and science policy dialogue, through the development of guidance documents (e.g. disseminated via blog posts and social media) and training/support of individual researchers (e.g. via training companies *Fast track impact* and *Impact Dialog*).

In addition to providing academic insights, the social science methods that have been chosen for this research are also designed to identify best practice examples that can be shared amongst their peers to inform ongoing policy and practice *ad hoc*, rather than relying on *post-hoc* external evaluations. Research participants will then be able to use these lessons learnt themselves and diffuse them amongst their peers and act as natural diffusion catalysts. The research findings could

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[15] http://www.biodiversity.de/ accessed on 15 May 2019.

therefore be used to improve processes of knowledge generation, co-generation and sharing by recommending best practice examples, e.g. for effective network structures. As such, the research aims to contribute to a more effective provision of scientific knowledge, increasing the likelihood of direct policy uptake into peatland policy and providing a valuable basis for the improvement of knowledge adoption and implementation strategies in the field of ecosystem service conservation and beyond.

1.5 Thesis outline

To address the objectives and research questions above the current knowledge about uptake of environmental knowledge for decision-making is summarised in *Chapter 2* and sets the scene for this research.

Chapter 3 describes and discusses the research design and the chosen mixed methodology to address the research questions and objectives in more detail. The two case studies are introduced. Justification for the choice of each element of the multi-method mix is elaborated. The chapter further explains how the stakeholder interviews were conducted and introduces Social and Bayesian network analysis. It also describes the stakeholder workshop in detail and how the questionnaire was conducted. Both quantitative and qualitative data exploration methods are explained.

Chapter 4 presents findings from in-depth social network analysis of the case studies at the science-policy interface. Five networks are explored and visualised for each case study. It analyses how the case study actors are linked through knowledge exchange activities relating to peatlands ecosystem service knowledge. Specific pathways through which knowledge has been transferred, received and exchanged via dialogue are identified. This is followed by an analysis and a discussion about which knowledge exchange interactions led to decisions being made and how this process is supported or hindered by the network structure. The results are discussed based on underlying theories/reasons behind the network structure that mattered for the uptake and implementation of peatland ecosystem service knowledge for evidence-informed decision-making in the case studies. Hereby central versus peripheral position of the actors and their roles within networks are analysed and discussed. The chapter concludes with a discussion of the development of centrality in the network for the success knowledge exchange and uptake over time.

Chapter 5 analyses key factors to maximise the probability of knowledge uptake and evidence-informed decision making in peatland policy and practice. This is demonstrated based on a Bayesian model of the decision-making network of each case study. The results are triangulated with additional qualitative data derived from the interview data that give in-depth insights to better understand results from the Bayesian network analysis.

Chapter 6 sheds light into the policy makers' perspective of successful knowledge uptake. It elaborates where policy makers sources there knowledge from. The chapter summarises answers about the most useful and least useful aspects of communication through interactions with researchers. Situations where trust increased and decreased are described and advice from policy makers for researchers are collected. Objective 4 is addressed in each of chapters 4-6 and is further explored in the concluding chapter.

The conclusion *Chapter 7* summarises the key findings from this PhD research. The chapter elaborates areas of future work and formulate target group specific recommendations for stakeholders at the science-policy interface to exchange their knowledge successfully with the other relevant stakeholder groups as this increasing the likelihood that their knowledge informs and is implemented in decision-making.

Chapter 2 - Literature review: Uptake of ecosystem service knowledge for decision-making

2.1 Introduction

The natural world, its functional ecosystems and biodiversity, are critical to human wellbeing, but the ecosystem services that the natural world provides have historically been undervalued in decision-making (Brauman et al., 2007). There is now more evidence than ever before that ecosystem processes and services are changing rapidly in response to climate change and other human drivers of change (e.g. IPBES, 2019; MEA, 2005; UK NEA, 2011, 2014; TEEB, 2008). However, there is limited evidence of the widespread use of this evidence in policy-making. There have been some attempts to assess the use of evidence through surveys of researchers publishing in international conservation journals about whether they perceive their recommendations have been implemented (Flaspohler et al., 2000; Ormerod et al., 2002), and there are a growing number of case studies of evidence uptake constructed by researchers available around the world (e.g. see the UK's REF2014 Impact Case Study Database[16]). Evaluations of the UK National Ecosystem Assessment found that the ecosystem approach and ecosystem services framework had systematically failed to be picked up by policy makers across the UK Government (Turnpenny et al., 2014; Waylen and Young, 2014). Cultural ecosystem services are particularly under-represented in policy discourses around the natural environment, despite a rapidly growing evidence base in this previously under-researched area (Kenter et al., 2014).

Given the range of ecosystem services that may be affected by policy decisions, it is important for members of the policy community to understand the relevant evidence-base. This thesis considers how these relevant stakeholders gain such ecosystem service knowledge, considering the sources of information they draw upon and how knowledge is exchanged between members of the case study networks these decision-makers are part of. Drawing on the concept of the Knowledge Hierarchy (Zeleny, 1987; Ackoff, 1989), data is transformed into information when it is analysed

[16] http://impact.ref.ac.uk/CaseStudies/ accessed on 9 May 2019.

and interpreted and information becomes knowledge when it is understood in a given context. Here, social, cultural and political contexts and worldviews as well as power relations, influence how the information in interpreted (Jensen et al., unpublished). Bandura (1977) furthermore proposed that all knowledge is formed through "social learning" interactions. However, it is important to appreciate that there are different perceptions of what it is possible to gain knowledge about (ontology) and how knowledge is gain, and so what constitutes valid knowledge (epistemology). On one hand there are objectivist approaches, where it assumed that it is possible to gain knowledge of objective reality, and these tend to be linked to positivist methods for collecting and interpreting data and information. On the other hand there are more subjectivist approaches that suggest there is no single objective reality. Instead there may be many different, equally valid perspectives on any given issue, and so data and information must be collected and interpreted using more subjective and interpretive approaches that recognise different perspectives and interpretations (Moon and Blackman, 2014). How information is treated and knowledge is used by a decision-maker will depend very much on their ontology and epistemology.

Environmental, including peatland, policies require information gathered from a wide range of knowledge types. This includes scientific knowledge, which is mainly backed up by peer-reviewed literature, but also knowledge from peatland practitioners and of course policy actors themselves. By the nature of my methods it is only possible to capture explicit knowledge, not implicit (and by definition certainly not tacit (Reed et al., 2013)). In the policy sphere, implicit knowledge includes those unwritten rules of thumb that people use to assess the policy relevance or feasibility of policy options, or the strength of evidence or reliability/trustworthiness of a source providing evidence.

The final level in the Knowledge Hierarchy is "wisdom" or "enlightenment", which is defined as the use of knowledge "for good" (Zeleny, 1987; Ackoff, 1989). This emphasises the subjectivity of knowledge use and links knowledge to concepts of impact. Definitions of wisdom and enlightenment emphasise "effectiveness", that "added value" and "socially acceptability" (Rowley, 2007) and the ethical judgement needed to use knowledge to "act critically or practically in any given situation" (Jashapara, 2005, p. 17–18). Whether knowledge is being used "wisely" will clearly depend on the ontological and epistemological perspective of the person making the decision. As Reed et al. (2020) suggest, "impact is in the eye of the beholder; a benefit perceived by one group at one time and place may be perceived as harmful or damaging by another group at the same or another time or place" (p. 6).

The objectives of this chapter are to review current literature on uptake of environmental knowledge within decision-making and identify gaps to be addressed through the research. The chapter integrates insights from theoretical frameworks and empirical published evidence to explore key design considerations for the successful uptake of environmental knowledge for decision-making. It is structured as follows. The first section 2.2 deals with the need to design knowledge exchange strategies in order to facilitate successful uptake of environmental knowledge for decision-making. This is followed by a section addressing the representation of relevant stakeholders. The third part describes essential elements and theories for engagement of stakeholders, followed by two sections answering the question when and where this engagement should take place. The chapter ends by outlining the need for further research on evaluation of science-policy engagement strategies.

2.2 Designing knowledge exchange strategies

Knowledge exchange strategies need to be designed in such a way that they fit the context and issue at stake if they are to improve the prospects of knowledge uptake, according to evidence from sustainable land management (De Vente et al., 2016). Previous research, in contexts ranging from the health sector to marine biodiversity, has suggested that the design of effective knowledge exchange requires an understanding of current policy and practice issues and clear objectives (Haines et al., 2004; Mea et al., 2016). Work on conservation conflicts also suggests that clarification, and transparent communication, of the motivation and goals of different stakeholders also help to support knowledge uptake (Redpath et al., 2013). Operationalising the concept of ecosystem services and protecting biodiversity demands common goals and areas of mutual benefit need to be identified during the design phase of a project (Bugter et al., 2018; Carmen et al., 2018). According to Carmen et al. (2018), who studied ten socio-ecological case studies from different countries, levels of governance and ecosystems, the identification of common goals enables planning for win-win situations for all stakeholders involved. All steps in the research project should be communicated transparently. If the collaborative team focusses and regularly reflects on and adapts their strategies, the likelihood for maximum knowledge uptake and further impacts of the project increases.

According to Mea et al. (2016), knowledge exchange and dissemination strategies should be designed before the start of the research project. The BiodivERsA FIREMAN project, for example, involved stakeholders at the proposal writing stage, which allowed for a sense of ownership to build (Durham et al., 2014). Evaluation of further BiodivERsA projects indicated that more project leaders would have liked stakeholders to input at earlier stages of the project (Durham et al., 2014). Durham et al. (2014) conclude with the recommendation to carry out pre-proposal scoping exercises to enable stakeholder groups to input into early project planning.

To ensure effective knowledge uptake, a long-term strategy is required compared to one-off knowledge transfer, so that trusting relationships can be formed and therefore knowledge uptake improved (Cairney et al., 2016). Furthermore, effective knowledge exchange strategies need to identify all relevant stakeholders and define the target groups (see stakeholder representation 2.3 below) and define the methods, tools and media accordingly (Mea et al., 2016).

Credibility, relevance and legitimacy (CRELE) and iterativity (Sarkki et al., 2015) are also seen as key prerequisites for successful science-policy interactions (Farrell et al., 2006) and need to be considered and planned for from the outset. However, these widely used criteria can be difficult for the evaluation of the success of science-policy interfaces (Heink et al., 2015). Dunn and Laing (2017) also criticised the CRELE concept as it appears to rely only on the science perspective. Instead, in reflecting policy makers' concerns, they contend that applicability, comprehensiveness, timing and accessibility (ACTA) are principal criteria for successful science-policy interactions. Relevance is also highlighted and is deemed important for both sides, whereas credibility and legitimacy did not resonate with the policy makers as much.

Last but not least, in order to successfully implement well designed knowledge exchange strategies, sufficient time and financial resources are essential (Reed et al., 2014). However, to date no recommendations for an optimal amount of financial resources or correlations between resources and effective knowledge uptake have been published in peer-reviewed literature.

2.3 Stakeholder representation and connection

For successful uptake of knowledge into decision-making, the participation[17] of different stakeholder groups is necessary. Effective stakeholder representation has been shown to increase levels of learning and trust between participants, whereas unrepresentative or restrictive participant selection may lead to fewer positive social impacts and greater potential for conflict.

[17] *Participation* is a process where stakeholders and publics (e.g. individuals, groups and organisations) choose to take an active role in making decisions that affect them (Reed, 2008).

This is according to findings and best practice lessons learnt in the stakeholder engagement handbook of BiodivERsA - a network of national funding organisations promoting pan-European research for the conservation and sustainable management of biodiversity and ecosystem services (Durham et. al. 2014). Effective dissemination, engagement and knowledge exchange strategies should therefore identify the target groups and select the methods and tools to reach out and engage with them considering each of the target groups and objectives (Mea et al., 2016). This requires an effective stakeholder analysis and appreciation of social networks and diffusion theory.

2.3.1 Stakeholder analysis

Stakeholder analysis methods are often applied to enable researchers to understand which individuals, groups and organisations have a stake in the issues they are researching. The goal is to systematically identify all relevant stakeholders regularly as part of the research or project cycle (Reed et al., 2018). Here scientists need to be aware that they are not the only stakeholder group influencing policy decisions, but only one competing group of actors (Cairney et al., 2016). Furthermore, a systematic stakeholder analysis does not only include the usual suspects, but also hard-to-reach stakeholder groups and those who could be disadvantaged or harmed by the research or research results. The outputs of a stakeholder analysis can be used either to prioritise or to even deprioritise stakeholders and stakeholder groups as target groups within an engagement strategy (Timotijevica et al., 2019). Information about stakeholders included in the process, based on insights from the stakeholder analysis, may then inform the design and facilitation of the process to protect the needs and interests of stakeholder groups that might otherwise be negatively affected by the research. This can lead to an increased likelihood for more beneficial outcomes for a wider range of stakeholders as has been studied for example by Young et al. (2013), in the context of the research project SPIRAL exploring: 'Science-Policy Interfaces for biodiversity: Research, Action and Learning' and De Vente et al. (2016) in the context of sustainable land management.

Stakeholder analysis typically considers the relative interest, influence and benefit of different groups to categorise or prioritise stakeholders for inclusion into the decision-making processes. The potential interests of stakeholders include the values, beliefs and norms that underpin those interests, as they pertain to the issue or decision being considered (Varvasovszky and Brugha, 2000), and can include the temporal immediacy (urgency) of stakeholders and their interests

(Mitchell, 1997) and their proximity to the decision (i.e. how frequently a stakeholder group comes into contact with the decision or the environment in which the decision is being made; Jones, 1991, Suchman, 1995). The level of influence over that issue or decision can manifest itself in a variety of ways. This included the power arising from different rights such as the legal, property, consumer, or user rights linked to the decision, the process through which the decision is made, the decision outcome, or the environment in which the decision is made (Jones, 1991; Harvey and Schaefer 2001); the moral legitimacy or fairness or stakeholder claims to inclusion and decision-making power, including the need to include under-represented or marginalised groups (Suchman, 1995; Holifield and Williams, 2018). These two key criteria are typically evaluated via an interest-influence matrix (Varvasovszky and Brugha, 2000; Polonsky and Scott, 2005). This approach is usually followed by classification of stakeholders as "key players", "context setters", "subjects" and "the crowd" (Reed et al., 2018). In order to improve the impact of the research, Reed et al. (2018) proposed a third category in the stakeholder analysis beyond interest and influence, namely benefit, by asking who is likely able to benefit (or not) from an engagement in the research. It should also be noted that stakeholder analysis can only be a snap-shot in time, and stakeholders and their interests and influence are typically dynamic, which means that the analysis should be conducted regularly during (intermediate) engagement strategy evaluation phases (Reed et al., 2018).

2.3.2 Diffusion theory and social network analysis

Having identified relevant stakeholders does not ensure that everyone knows each other, hence that they are connected in social network nor that they diffuse information. However Cairney et al. (2016) point out that policy is routinely made in networks. It is important to look into important ingredients that are relevant for such networks and the knowledge and diffusion process. Once relationships between network actors are formed they can be studied in depth via social network analysis tools. The research field of social network analysis has been growing and developing during the past years, where numerous social sciences are involved (e.g. Freeman, 2004). Social network analysis is a sophisticated tool allowing the study of relationships between actors, including knowledge flows (Prell et al., 2009) and levels of trust and influence (Reed et al., 2009). Both authors applied social network analysis within the context of natural resource management. Salpeteur et al. (2017) describe social network analysis as a flexible tool that enables to study different and useful perspective on complex social dynamics including in environmental management issues. This is particularly important given longstanding evidence which suggests that stakeholders prefer to consult people they know, rather than accessing research documents, if they are in need of new information (Mintzberg, 1973). Cairney et al. (2016) particularly emphasise how policy makers rely on links with people they know and trust. In making decisions, people therefore seem to be more influenced by direct and personal contacts than by mass media (Rogers, 2003). The question therefore arises, are there trusting connections policy makers can draw from to inform their decisions?

As stakeholders interact in their own personal and professional networks, it is therefore important to look closer at who is part of these social network structures to enable trust building and optimal knowledge exchange (Buskens, 2002). A second question is who enables, supports and enhances the development of long-term trusting relationships to enhance knowledge exchange or co-production of knowledge. Such an approach enables a deliberate stakeholder management, including the empowerment of influential groups that can further help to diffuse ideas and knowledge through their network connections (e.g. Prell et al., 2009).

Furthermore, it needs to be recognised that policy makers are not the only stakeholders making decisions. Other stakeholders make decisions too, not only based on dyadic communication but also via collective decision making processes including multiple communication interactions and multiple stakeholder involved over time. Miner (1984) found that group decision-making is better than individual solutions.

Rogers' work on diffusion of innovation (2003) builds a foundation for social network analysis and knowledge transfer and exchange. Diffusion of innovations theory attempts to explain how new ideas and practices as well as knowledge spread within and between stakeholder groups via social networks linkages (Rogers, 2003). This has been done already in the 50s by Bavelas (1948; 1950), who experimented within small groups and found that network structure affected the speed as well as the efficiency of knowledge diffusion. As such, this is one of the theoretical foundations of Social Network Analysis, especially centrality (Freeman, 1978), providing an explanation for the factors influencing the spread of knowledge, ideas and practices through social networks and hence decision-making and the uptake of (ecosystem service) knowledge. Rogers addresses the topic of diffusion networks and specifically looks at models of communication transfer. In this thesis I extend on this and look specifically on both one-way knowledge elements (transfer and reception) as well as studying the impact of two-way exchange of knowledge on decision-making.

Furthermore, the *homophily* model, where interacting individuals are similar in their characteristics, as well as *heterophily*, where communicating individuals are very different (McPherson et al., 2001), are important for the diffusion of new ideas. According to Fischer and Jasny (2017, p.3) and based on McPherson et al. (2001) "homophily refers to the socio-psychological tendency for people to associate with others who are similar to them, i.e., share beliefs and values, or who are accessible because they share social strata or physical locations." One of the simplest homophilic characteristic is space. People are more likely to have contact with those who are closer to them in terms of geographic distance than those who are distant (Henry, 2011, McPherson et al., 2001). Furthermore, if they share same or similar occupations (Henry, 2011, McPherson et al., 2001). This has been for example shown in a case study research that worked with a community of fishers along coastal Kenya where ecological knowledge was mainly transferred within occupation-related groups - fishermen using the same gear (Crona and Bodin, 2006). These two will be focussed on in chapter 4 and 5, bearing in mind that multiple characteristics play a role in the diffusion process. Environmental governance and its implementation in research projects and conservation management requires these different views and opinions, which means they need to be recognised and discussed (Bodin and Crona, 2011). Both types of connection offer benefits. Homophily is thought to enhance tacit knowledge transfer (Cross et al., 2001), but this might remain within a homophilic network community and not spread beyond (Reagans and McEvily, 2003). High levels of homophily also sometimes reduce diversity and therefore limit the access to distant resources (Krackhardt and Stern, 1988), whilst connections to heterophilic actors can serve to increase the ability to exchange complex ideas to a wider range of audiences (Reagans and McEvily, 2003) and increase productivity.

Within diffusion theory, a critical mass of opinion leaders needs to be reached in order to spread ideas. This can be done, for example, by calling relevant, well-known stakeholders onto the project or research management committee (Andrews, 2012) or as spokespersons. Once a *critical mass*, the point after which further diffusion of an idea, such as biodiversity protection, becomes self-sustaining (Rogers, 2003). Before this can happen *structural holes*, or knowledge gaps between separate networks with complementary resources or information (Burt 1992), have to be closed. Structural holes exist between two individuals if they are not connected via another actor (Burt, 1992; 2009). However, structural holes in the network can be bridged through connections with external stakeholders (Reagans and McEvily, 2003). This is important as structural holes decrease the number of potential strong ties in the network structures and are acting as a barrier to knowledge transfer. To ensure that knowledge is used by the target group, strong ties are essential

(Levin and Cross, 2004). Strong ties are more likely to be trusting relationships (Coleman, 1990; Crona and Bodin, 2006; Cross and Parker, 2004; Friedkin, 1998; Kadushin, 1966; Newman and Dale, 2004; Tsai and Ghoshal, 1998; Wellman and Frank, 2001). Therefore, strong ties have also been used in the literature as proxies for trust (Gulati, 1994).

However, evidence, e.g. from natural research management suggests that diverse and innovative new ideas diffuse best through weak ties (Prell et al., 2009). A weak tie is often characterised by less frequent communication. Research has shown that weak ties tend to exist between dissimilar, heterophilic actors (McPherson et al., 2001; Prell et al., 2009). Weak ties allow for knowledge exchange amongst heterophilic network connections and provide access to new knowledge/information (Granovetter, 1973). Levin and Cross (2004) define these relational connections as being trusted weak tie relationships providing new non-redundant knowledge to the network actors. Transfer of tacit knowledge is more difficult and slower across different networks (Reagans and McEvily, 2003; Zander and Kogut, 1995). Within the context of resource management, weak ties can make a network more resilient and adaptive to environmental change. A potential drawback of weak ties is that they may be easy to break. In addition, actors sharing weak ties may lack the trust and understanding needed for in-depth dialogue over environmental issues (Burt, 1992, 1997, 2000; Newman and Dale, 2004; Reed et al., 2009). The development and maintenance of strong ties requires more resources, e.g. time (Reagans and McEvily, 2003). Based on a sample of 102 US organisations Pérez-Nordtved et al. (2008) found that knowledge transfer between these organisations was most effective and efficient if the quality of the relationship between knowledge source and recipient is high, as more frequent interactions led to a generation of a “common language”, more openness and cooperation and built trust. Trust enables the network actors to be confident that the exchange knowledge will not be misused (Krackhardt, 1990; McEvily et al., 2003). In order to build networks consisting of homophilic, heterophilic stakeholders, including weak ties and allowing for the development of strong ties as well as the bridging of structural holes, a deliberate network management is useful and will be discussed in the next section.

2.3.3 Knowledge brokers and bridging organisations

If interactions between stakeholders are well facilitated the uptake of research can increase (Haines et al., 2004), so can the quality and relevance of the evidence (co-)produced if it includes multiple stakeholder perspectives (Bednarak et al., 2018). Both individual stakeholders as well as multi-stakeholder networks play their roles in knowledge exchange, co-production and knowledge uptake processes. Besides these stakeholders' individual roles, a group that is increasingly recognised as playing an integral part to support knowledge uptake, are intermediaries often called knowledge brokers (Bielak et al., 2008; CHSRF, 2003; Cvitanovic et al., 2017; Lavis et al., 2003; Meyer, 2010; Russel et al., 2010; Ward et al., 2009 a,b,c). Olsson et al. (2004) call these people key stewards. They have also been referred to as policy entrepreneurs (Shannon, 1991; Kingdon, 1995), bridging agents or science-diplomats. According to Folke et al. (2005, p. 454) they can act as "interpreters, facilitators, visionaries, inspirers, innovators, experimenters, followers, and reinforcers". With the support of these legitimised interfacers the integration of knowledge into environmental governance could be strongly enhanced (e.g. Cvitanovic et al., 2017). Given all these different terms, the term knowledge broker has been chosen as it is used most widely.

So who are the actors that support stakeholder engagement and integration of knowledge into decision-making? Given the ever increasing number of theories and models of knowledge implementation it is interesting to note the limited focus about the people who implement the integration of ecosystem service knowledge. Thinking about the science-policy interface the obvious stakeholder groups are actors from the research and policy communities. However not only the research and policy community play an important role, also individual practitioners etc. This makes sense given that they will implement decisions on the ground – literally.

The questions remain: Why are knowledge brokers successful? What are their roles and skill-sets? All it takes for good knowledge exchange are skilful people according to Olsson et al. (2004). The skills and required tasks of knowledge brokers can be structured as: first they support the initial connections of relevant stakeholders by conducting and facilitating the development of an in-depth stakeholder analysis together with the project team (see 2.3.1) and design the knowledge exchange process. This is followed by the initiation of deliberate network management (see 2.3.3) where the knowledge brokers support stakeholders to communicate with each other, for example by developing and communicating a common vision and goals (Bielak, 2008; Schiffer and Hauck, 2010). Folke (2005) points out that the problem definition is the crucial aspect of the knowledge exchange process. Third knowledge broker enable sustained long-term trusting relationships for continuous exchange amongst the involved stakeholder groups (2.5.4 below). Here the knowledge exchanged strategy need regular reflection and adaption over time (Folke, 2005).

As each stakeholder has their own individual, differing daily schedules, tasks, languages, norms, value set and belief systems, skilled knowledge brokers can translate knowledge and information into a common language, as has been successfully shown by national science-policy interfaces, such as the NeFo project in Germany (Neumann et al., 2012) as well as developing a common language amongst the stakeholders themselves, as Ernstson et al. (2010) succeeded in their local study on urban ecosystem services in Stockholm. If stakeholders are more open for thoughtful dialogue they can learn from each other (Cairney et al., 2016). Increased understanding for each other's viewpoints and constraints can lead to increased trust amongst collaborators in the network (Cairney et al., 2016; De Vente et al., 2016). Knowledge brokers can also mediate amongst differences and create an atmosphere of openness and understanding as a foundation for knowledge exchange to take place. Once participants have a better holistic problem awareness and reflection, consensus, acceptance and implementation of tailor-made solutions is more likely (De Vente et al., 2016) which enables the delivery of more relevant, useful, and effective policy (Cairney et al., 2016). All of this can lead to more empowered and confident stakeholder (De Vente et al., 2016). Successful stakeholder engagement requires long-term engagement. Relationship building takes time and resources, however does not always guarantee success (Oliver et al., 2018), but likelihood for success increases long-term (Everard et al., 2016). This allows to incooperate common norms, create collective ownership and shared responsibility as drivers for successful engagement over time (Everard et al., 2016). This is important to build long-term trusting relationships (e.g. Oliver et al., 2019). In order to successfully develop networks between communities of scientists and policymakers a relevant competencies of knowledge broker is therefore a good understanding of both political processes as well as of the scientific work environment according to Cairney et al. (2016) and Neumann et al. (2012), who report best practice at the national scale of a science-policy interface for biodiversity and ecosystem service protection.

But these are not all the skills and tasks amongst knowledge brokers' portfolio. Knowledge brokers enable two-way dialogue, capture disagreements and deal with different competing definitions of used terms (Bielak, 2008). To be able to manage group dynamics and emerging conflicts, a good knowledge of the vocabulary of the involved stakeholders is useful. So they can act as translators and interpreters whilst being facilitators and moderators of discussion between the teams and relevant external stakeholders. This helps for improving the capacity building in teams, so they are enabled to effectively exchange knowledge into the future (Ward et al., 2009c). Facilitation of knowledge management is a further skill and requires different tasks. Knowledge brokers can identify knowledge gaps and needs (Folke, 2005) and locate, manage and tailor the knowledge accordingly. They facilitate the flow of information and knowledge at the relevant scale – local to international – and apply it to the right ecosystem management context. According to Folke (2005), knowledge brokers support the formation of social memory when they act as "information brokers" and make sure that "adaptive co-management systems include knowledge carriers, knowledge generators, stewards, leaders, and people who make sense of available information" (Folke, 2005, p. 454). Their tasks include ensuring that knowledge is assessed for relevance, credibility and usefulness, supporting the creation of new knowledge and finally actions to condense, summarise and synthesis the resulting knowledge into understandable formats, such as short reports that are disseminated amongst the involved stakeholders (Ward et al., 2012).

In order to change and improve knowledge exchange it is important to acknowledge the role these knowledge brokers play (Bielak, 2008) as they often initiate key processes that are required in ecosystem management (Pinkerton, 1998). One important aspect in this regard is that academic and political institutions need to legitimise knowledge brokerage, making it a more recognised role that they are allowed to play. If knowledge brokers are valued and have earned respect by both communities (Bielak, 2008), these individuals can fulfil their key functions within science-policy networks, all while remaining political independent (Folke, 2005).

At larger multi-stakeholder scales, institutions of various sizes and clusters of individuals play a role to bridge the science-policy divide. The integration of bridging organisations can be key to successful implementation of knowledge exchange strategies (Berkes, 2009). Even though every institution at the science-policy interface still consists of many individuals, multi-stakeholder bridging organisations can provide benefits to enhance knowledge uptake for decision-making as they allow for interaction enabling to build common ground amongst stakeholders holding diverse beliefs and therefore increase understanding and acceptance.

Amongst the multi-stakeholder bridging organisations are departments located in both the academic as well as policy worlds. Also multiple NGOs, companies, public(s), industry, media any others can function as bridging organisation. Some of these might be located or positioned closer to science or to policy or neither and try to remain independent. Amongst these are so called science-policy interfaces, from national scale (e.g. the German or Belgian Biodiversity platforms) to international scale (e.g. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Convention of Biological Diversity (CBD) with its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), Intergovernmental Panel on Climate Change (IPCC) or the United Nations Convention to Combat Desertification (UNCCD) Science-policy interface (SPI)). Whilst studying adaptive governance of social-ecological systems, Folke et al. (2005) describes the task of bridging organisations as to connect local stakeholder and communities with other scales of organisations by providing resources and knowledge. They therefore function as a boundary organisation by communicating, translating, and mediating scientific knowledge so it is relevant to policy and action. Bridging organisations can tap into their own networks and can therefore mobilise knowledge and develop social memory (Folke et al., 2005). Bridging organisations can support to find common interests and aims, develop common norms and identity, resolve conflicts, which all in turn helps to develop trust (Best and Hall, 2006). They can do so by providing space and facilitation, leadership. A recent example is the Natural History Museum in Berlin[18], that provides space for dialogue for all stakeholders involved in climate action include activists from Fridays for Future[19].

The efficient use of bridging organisations and individual knowledge broker can lead to a reduction of (mainly nonmonetary) transaction costs of the stakeholder engagement process (Folke, 2005; Wreford et al., in press; Zheng et al., 2008), e.g. as they support the formation and improvement of trusted network formation and facilitate knowledge exchange amongst the involved stakeholders and reduce the risk to loss trust, which is often difficult to rebuild (Lacey et al., 2018). In order to create necessary organisation culture bottom-up movements or wider organisational change might be needed. Finally it must be noted that most of the above can still be boiled down to the tasks of key individuals, apart from creating and using the identification, reputation and therefore credibility that comes with being a part of an organisation or institution.

2.3.4 Deliberate network management

Network structure can improve environmental governance and it is possible to facilitate network development (Bodin and Crona, 2009). Sandström et al. (2013) suggest that network characteristics such as a previous collaboration structure[20], deliberative network actor selection and commitment are important to ensure legitimacy in environmental co-management projects. Successful network management needs to consider which stakeholders to include and engage to

[18] https://www.museumfuernaturkunde.berlin/de/presse/pressemitteilungen/berliner-naturkundemuseum-unterstuetzt-weiter-friday-future-dialog accessed on 24 April 2019.
[19] https://www.fridaysforfuture.org/ accessed on 24 April 2019.
[20] With "previous collaboration structure" we refer to connections that existed prior to a new network formation, e.g. through a research project. According to Sandström et al. (2013) these actors bring in experiences and the overall projects decisions are effected by those pre-existing connections.

enable best possible knowledge uptake. Therefore, network managers need to be aware of the wide range of interested and influential actors in a multi-level stakeholder landscape (Cairney et al., 2016). The first task for knowledge brokers is always to connect people with each other (e.g. Wilson, 2002). In order to bring stakeholders together network managing tasks include the incorporation of different perspectives from both homophilic as well as heterophilic stakeholders. Furthermore, value pluralism amongst stakeholders at science-policy interfaces addressing biodiversity (Tinch et al., 2018) and well-established beliefs need to be recognised both in health as well as environmental science studies according to Cairney et al. (2016). There are differences in academic and political 'cultures', and linked to this there may be significant differences in the use of language, including the use of jargon. Research timescales tend be much longer than policy cycles, and this mismatch can be a significant barrier to the timely use of evidence in policy (Cairney et al., 2016). All of these issues must be reflected upon and a common understanding about them developed by involved stakeholders. This process is ideally facilitated by professional knowledge brokers to connect diverse polycentric governance structures (Folke et al., 2005). These connections are important for the production of knowledge and knowledge exchange, hence the network structure itself is important (Levin and Cross, 2004), hence a deliberate network management makes sense.

Stakeholders usually have an extended network themselves and/or access to networks through other key players. It is worthwhile to include people who are already present (Bielak, 2008), but over time remain open and reflective to not using the same people over and over again and missing out on other important players. To achieve this Bielak (2008), who draws on examples from three national environmental ministries, suggests to develop and update a list of the 100 most important influencers. In this way, key bridging individuals and bridging organisations can "create nodes of expertise" through linking actors (Folke, 2005, p. 459). Both the initiation (Folke, 2005) and maintenance of networks are important tasks. Knowledge brokers are able to build functional links in social networks within and between organisations. In order to do so, good communicational skills are essential. Deliberate network management can have effects on knowledge transfer if it invests in informal networks (Reagans and McEvily, 2003). The authors continue that informal networks can positively influence the success of knowledge transfer in interpersonal networks, as they are able to affect the willingness and motivation of the network actors to invest resources in knowledge sharing.

Furthermore, managing power dynamics are vital for the effectiveness of the outcome of stakeholder engagement processes (Reed et al., 2018). They authors continue in saying that professional facilitation and mediation can enable the equal participation of stakeholders, so everyone can equally contribute knowledge that will influence the outcome. Existing conflicts can be resolved and a culture of understanding and trust established.

Trust plays an important role in networks (Buskens, 2002; Ansell and Gash, 2008; Klijn et al., 2010) and empirical research has shown that the level of trust affects the performance of these networks (Provan et al., 2009). Interpersonal trust can be developed between individuals and include a willingness to accept risk or be vulnerable in the relationship (Mayer et al., 1995; Stern and Coleman, 2015). Competition amongst network actors can limit the success of knowledge transfer (Argote, 1999; Reagans and McEvily, 2003) and network management highlights the need for interactions and trust building in order to internalise externalities and create stable environments for dialogue (Klijn and Koppenjan, 2012). To create trustworthiness, repetitive, ongoing interactions are required (Chang et al., 2010). Strong ties enable the formation of trust (Reagans and McEvily, 2003) whereas weak ties do not have such regularly interactions and may therefore lack the trust and understanding that is needed for meaningful dialogue over environmental issues (Reed et al., 2009). Furthermore, when environmental messages are transferred, trust was identified as an important factor determining credibility of the messenger and consequently the effectiveness of the arguments that have been used (Tinch et al., 2018b; Primmer et al., 2015). Knowledge brokers have an understanding the dynamic nature of relationships and can manage power dynamics. This is particular important for levels of trust. In social networks trust is important for predicting conflict and identifying windows of opportunity (see more on windows of opportunity in section 2.5.2.). Insights into these temporal dynamics can also be useful for building trust and other forms of social capital through targeted interventions (De Vries et al., 2014). Knowledge brokers can achieve this by unearthing stakeholder perspectives and creating a room for trust to develop.

The impact of network centralisation

Network centrality measures can also give indication for the potential success of the exchange output of the network connections. Centralised networks are helpful for the initial phase of forming groups and building support for collective action (Crona and Bodin, 2006; Olsson et al., 2004). Centralised networks can perform simple tasks more efficiently than decentralised ones. This is the case if one small group of actors are very centrally positioned in the network, with other actors positioned in the periphery (Leavitt, 1951; Shaw, 1981). Various studies from different context, e.g. agrobiodiversity conservation and many more, explored the effect of individual actors centrality in knowledge exchange networks, showing that the more central actors are more knowledgeable than peripheral located actors (e.g. Calvet-Mir et al., 2012). These actors not only handle the majority of the knowledge exchange, but also decision-making processes and are hence more efficient. At beginning of a project phase centralised structures have shown to be effective for coordination and dissemination of information, which allows to build understanding and consensus (Leavitt, 1951). If the core group of the network receives a new information it can efficiently diffuse to the rest of the network (Prell, 2012). However, Leavitt (1951) and Shaw (1981) showed that decentralised structures perform better when tasks are complex. Environmental governance issues can be considered as complex. Centralised networks are therefore disadvantageous for long-term planning and problem solution. These more long-term goals require a more decentralised structure. These network structures include more ties, combined of weak and strong ties among stakeholders and bring stability into the structure as the network does not collapse if central positioned actors are removed from the network (Crona and Bodin, 2006).

Investing in diversifying networks might take time, but are likely to be more valuable long-term (Reagans and McEvily, 2003). Network management is important but not easy (Klijn and Koppenjan, 2012). According to evidence from environmental studies, it is unlikely to find one optimal network structure that fits for all times, as the optimal structure depends on the phase of the stakeholder engagement process (Crona and Bodin, 2006), but decentralised structures seem important for long-term success of network (Reed et al., 2009). Therefore, the network management approach needs to remain flexible (Nesshöver et al., 2016), regularly evaluate and be adapted on the basis of evaluation findings.

2.4 Processes and models for stakeholder engagement

This section introduced models of stakeholder engagement and knowledge exchange and discusses their strengths and limitations. Furthermore, factors for successful participation, engagement and co-production are discussed.

2.4.1 Models of stakeholder engagement and knowledge exchange

Despite different strategies for knowledge transfer and exchange, evaluations for evidence-based knowledge exchange are lacking according to Mitton et al. (2007) and also Fazey et al. (2014) who analysed 135 peer-reviewed evaluations of knowledge exchange from diverse disciplines and indicate strong relationships between the fields of study (e.g. health care, environmental management). Compared to a mere knowledge transfer (one-way communication that "pushes" from the knowledge producer to the users of research), knowledge exchange requires stronger interaction between researchers, decision makers and further stakeholders (Lavis et al., 2003). Knowledge exchange has been defined as an interactive interchange of knowledge between research users and research producers (Kiefer et al., 2005). The purpose of knowledge exchange and therefore knowledge adoption is the increased likelihood that research evidence and knowledge will be used in policy decisions. Unfortunately, as Turnpenny et al. (2014) show, the implementation and uptake of scientific knowledge about ecosystem services systematically failed to be picked up even within the UK environment ministry and knowledge exchange therefore should receive more attention than mere transfer.

To ensure an effective management of ecosystem services, Cowling et al. (2008) propose an operational model with three key elements: 1. socially relevant, user-inspired research geared for implementation; 2. stakeholder empowerment from the outset; and 3. development of an adaptive management strategy embedded in learning organisations that represent the sector of concern for the final decision-making. According to the authors, the implementation of the model will require changes to how research generates knowledge. Thus researchers need to be responsive to other stakeholder needs and work with interested and affected groups that have different norms and values which might differ to their own (see *heterophily* above). According to Cowling et al. (2008) researchers should act as facilitators of knowledge for other stakeholders and they need to be prepared to be engaged beyond the usual process of publishing in academic high-impact journals. Universities (and other funding agencies) need to recognise the importance of transdisciplinary research through increased funding and status (Benner and Sandström, 2000; Roux et al., 2010). Further requirements for the implementation of the proposed model are time and money, especially transaction costs (Gatzweiler, 2006). As the model invisions bottom-up decision-making (Cowling et al., 2008) institutional support is needed to legitimise those outcomes (Olsson et al., 2006).

As communication at the interface between science and policy mainly follows a 'linear model' (Pielke, 2007), this might explain why knowledge about ecosystem services is only slowly diffused within even the environmental ministry and therefore limits the implementation and uptake of scientific knowledge into decision-making (Turnpenny et al., 2014). This model assumes that scientists provide research evidence to policy makers, mainly by scientific publications, and expect the public to act upon their findings and policy makers to then come to well informed decisions. However, some global assessments have been shown to have limited policy impact because they applied this communication model (Young et al., 2014). Therefore, a two-way dialogue between researchers and policy makers might be more suited to find solutions to safeguard the environment (Koetz et al., 2011; Young et al., 2014). Within the research field of social network analysis furthermore the model of two-party (dyadic), two-way dialogue and knowledge exchange is studied in-depth (Prell, 2003). This enables to explore exact pathways of knowledge within networks, shedding light into effectiveness of both one-way and two-way knowledge exchange.

2.4.2 Factors for successful participation, engagement and co-production

There is an increasing pressure on the research community to successfully engage and even co-produce knowledge to increase its uptake and hence impact (Oliver et al., 2019). Co-producing of research knowledge engenders greater potential to increase the uptake and impact of the work (Barber et al., 2011; Goodyear-Smith et al., 2015; Oliver et al., 2015). *Knowledge co-production* refers to the active involvement and engagement of multiple actors in the production of knowledge from various sources in order to find solutions for complex governance problems, in this case of this thesis, solutions to pressing environmental issues on peatland ecosystems and their services, through an facilitated and designed process (e.g. Frantzeskaki and Kabisch, 2016; Voorberg et al., 2014). In their perspective piece, Norström et al. (2020) suggest four principles for impactful knowledge co-production: context-based, pluralistic, goal-oriented and interactive. According to Nel et al. (2015) co-production requires bridging skills (e.g. by knowledge brokers and bridging organisations, see 2.3.3) in order to facilitate iterative interactions of stakeholders through toward common vision and action. In their study of regional conservation planning projects in South Africa aimed at identifying areas for conserving rivers and wetlands, Nel et al. (2015) applied the knowledge co-production concept over a duration of 4 years. The resulting co-produced maps and information integrated diverse knowledge types of over 450 stakeholders and represented >1000 years of collective experience. Co-production networks enables both sides to learn about and appreciate the constraints under which they themselves, as well as the other side, work (Cairney et al., 2016). If stakeholders at the science-policy interface were to work more closely with each other based on respectful dialogue this may help to produce more relevant, readily applicable and sustainable policy products (Cairney et al., 2016; Nel et al., 2015).

Having said this, Reed et al. (2018) proposed a theory of participation and what makes successful stakeholder and public engagement in environmental management. They introduced a typology of stakeholder engagement ranging from communication to co-production, arguing that one-way communication can be appropriate for certain contexts and purposes. They argue that whatever the level of engagement, the outcomes depend more on the design of the process and its fit to purpose than the level of engagement chosen *per se*. Specifically, they propose four main factors influencing the outcomes of stakeholder engagement. These include (i) that socioeconomic, cultural and institutional contextual factors influence the outcomes of engagement; (ii) design factors need to be applied across this wide range of socio-cultural, political, economic and biophysical contexts – one important aspect for the design is the representation of relevant stakeholders and their interests transparently throughout the participation process; (iii) the influence of power dynamics on the effectiveness of engagement, where the literature shows that dialogue and cooperation amongst stakeholders can lead to longer lasting more sustainable outcomes compared to hierarchical settings and that deliberate democracy via a two-way dialogue compared to representative democracy through parliaments led to greater stakeholder empowerment and (iv) the need to consider the different spatial and temporal scales in which the participation processes are embedded – spanning from small rather short lasting interpersonal two-way interactions to national and international scales spanning over long timeframes (Reed et al., 2018).

Linked to this, empirical results from an analysis of participatory processes in multiple countries concluded that first stakeholders should be selected deliberately and include homophilic as well as diverse heterophilic actors (De Vente et al., 2016). Participation must be made easy and attractive. Relationships and trust building should be based on existing minimal trust and pre-existing network connections as discussed above in section 2.3.4. Participants are given decision-making power and all relevant information and knowledge is provided and shared transparently. Language and locations for meetings need to consider and adapt to the context of the participating stakeholders (e.g. workshops on the ground). A professional independent facilitator ensures fair and equal engagement, while also handling power dynamics (De Vente et al., 2016; Oliver et al., 2019; Reed et al., 2018) (more on knowledge brokers in section 2.3 above).

To conclude, there is evidence that successful stakeholder engagement is inclusive, engaging all relevant stakeholders including affected and influential actors. In this thesis, the focus is on stakeholders in two science-policy interfaces and international peatland policy makers. It is clear from the literature on stakeholder engagement that there may be many stakeholders with an interest in or who might be affected by or be able to influence these groups. However, as a study of the science-policy interface, this thesis does not attempt to identify these wider stakeholder networks, focusing instead on the operation of existing defined groups as they engaged with their networks.

2.5 Temporal scales

Besides content and format of the knowledge, Dietz et al. (2003) point out that for the distribution of information the right time is key. So when is the best timing for knowledge to be taken up most effectively for environmental decision-making? Temporal scales can cover everything from what time of the day, week or phase of the research project is best suited for impactful stakeholder engagement. What role does the frequency of knowledge exchange play?

2.5.1 Start early in times of stability

There has been a growing emphasis on early engagement with those with a stake in the knowledge exchange process (Bielak, 2008). In case of a research project aiming for knowledge uptake and policy impact, this might start with forming social ties and trusting relationships with interested parties before the project even starts. Once the research project starts, the joint formulation of research questions is important to make sure that expectations are clear, realistic and reflect common goals among all participants in the co-production process according to Bielak (2008) and Phillipson et al. (2012), who base their findings on examples and surveys on environmental research projects from Australia, Canada and the UK. Building trusting relationships as a basis for social networks takes time, and should therefore start early.

According to Olsson et al. (2004), the necessary and perhaps new links in social networks are best built during times of stability versus times of crisis or change. Furthermore, these links are also more likely to form between individuals and organisations that have similar characteristics, for example political ideologies, attitudes and interpersonal characteristics – this is the principle of homophily in social networks (McPherson et al., 2001). These social networks then may become extremely valuable during a time of crisis, when “windows of opportunity” for policy change are most likely to occur, this seems not the case e.g. when the huge wildfires broke out and affected Australians ecosystems and added negatively to global climate change in 2019 and beyond (Nolan et al., 2020). In that instance so far no one seems to focus on the damage the wildfire had on the affected areas, such as in the Blue Mountains, including their peatlands. Furthermore, the peatbog burning in the UK in 2019 led to the UK Peatland Programme to update their position statement on “Burning and peatlands”[21]. This requires a strong social networks holding a good knowledge base, however the strength of (pre-) existing network ties have yet to prove that this synthesised knowledge is taken up by decision makers and formulated into policy regulation. By studying and reporting from social-ecological systems (Folke et al., 2005) and the UK ecosystem assessment (UKNEAFO, 2014) the authors argue that in times of crisis, policy-makers are likely to draw upon informal social networks of actors whom they trust already. Investing in and subsequently using these relationships and networks at times of crisis to adapt and then promote relevant research findings may therefore be an important way for researchers to enhance their policy influence (Bednarek et al., 2018; Honig et al., 2014). Olsson et al. (2004), who studied social-ecological transformation for ecosystem management, suggest that rather than waiting for a crisis before formulating policy messages, researchers should invest time in developing informal social networks with members of the policy community based on trust and dialogue.

2.5.2 Openness and windows of opportunity

The literature argues that policy innovation is not a gradual and continuous process, but rather is episodic, with significant policy change occurring rapidly in response to external stimuli, such as crises. Depending on the nature of the external stimuli, policy actors that were previously resistant to change may become open to new policy ideas. The socio-technical systems literature conceptualises this as a ‘socio-technical transition’ (Rotmans et al., 2001; Geels, 2004; Kemp and Rotmans, 2005; Kemp et al., 2007). Following this school of thought, policy innovation is a process of co-production and practical application of new ideas by researchers and policy-makers, which is coordinated through institutions in safe places where these ideas can be tested and refined. Then, when these ideas become mainstreamed into multiple policies (usually in response to some sort of new problem), they have the capacity to disrupt stable societal structures and norms (the

[21] https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2020-03/IUCN%20UK%20PP%20Burning%20and%20Peatlands%20Position%20Paper%202020%20Update.pdf accessed on 3 April 2020.

‘socio-technical regime’) amongst the decision-makers, so that a transition to a new way of doing/deciding things is possible. Using the example of the massive peatland fires in Indonesia in 2015 reported by Nurhidayah et al. (2017): Forest fires occur every year, but in 2015 over 112,000 fire hotspots were active between August and October. This has catastrophic impacts not only on biodiversity, but also economic activities, harming respiratory health, but the resulting haze pollution from forest fires also affects neighbouring countries including Malaysia and Singapore, which places a strain on diplomatic relations. The most long lasting impact is added to the global atmospheric carbon worldwide. Total emissions for 2015 were estimated by Field et al. (2016) to be 380 Tg C, which equals 1.5 billion metric tons CO2equivalent. This is higher than the annual emissions of Germany. Nurhidayah et al. (2017) investigated the law and policy framework in Indonesia in implementing “Reducing Emissions from Deforestation and Forest Degradation” (REDD+) and conclude that while measures increased after the 2015 fires, such as peatland rehabilitation, a comprehensive mapping system, ministerial restructuring, and law enforcement are steps in the right direction, the underlying drivers of forest fires are not addressed yet (e.g. systemic agricultural practices at local level) or a holistic forest fire management program adopted. Tyre and Orlikowski (1994) describe this as a process of adaptation, where policy innovations build upon and refine existing policy measures more commonly than they introduce a completely new approach. According to Joosten (2011) peatlands have arrived in mainstream politics and need to stay mainstream.

The concept of “windows of opportunity” arose in the business management literature, to identify opportunities for step changes in technological adaptation in response to changing contexts (Tyre and Orlikowski, 1994). This concept has been applied in the context of environmental policy as a way of identifying opportunities for affecting policy changes that can promote sustainability (Meijerink, 2005; Nohrstedt, 2005). Folke et al. (2005) identify two types of policy window: problem-driven windows open when policy-makers perceive a problem as pressing and seek policy solutions; and politically-driven windows open when policy-makers adopt a particular ideology or theme for their time in administration, and look for problems to justify change which then point to policy solutions that are consistent with their chosen theme. If researchers are aware of the upcoming policy agenda (Cairney et al., 2016), they are able to provide solutions tailored to policy issues during times when policy makers have the opportunity to adapt them (Bednarek et al., 2018; Kingdon, 1984).

In the science-policy-sphere, as elsewhere, there are likely to be individuals and organisations who are innovators and early adopters, who may be open to new policy innovations earlier than others, who Rogers (2003) would refer to as 'laggards'. According to Rogers' (2010) diffusion of innovations theory, a number of factors can increase the speed with which policy innovations may be adopted, including: i) the characteristics of the policy innovation itself (notably its relative advantage in comparison to current policies, but also the observability, trialability, observability of effects, adaptability (or capacity for re-invention as policy needs evolve); ii) compatibility with current policies and political ideologies); iii) the way in which the policy innovation is communicated to policy-makers (including the modes and channels of communication, influenced by social network characteristics); and iv) the characteristics of the policy-makers and organisations being introduced to the innovation (including levels of prior knowledge and experience that can enable them to understand the risks and benefits of the proposed policy innovation, and their power or agency to affect policy change). The thesis focusses on the third factor of the diffusion of innovation theory.

2.5.3 Ongoing sustaining stakeholder engagement process

Once the knowledge broker and bridging organisations have supported the scientific and political actors to connect and communicate well with each other, the formation and sustaining of trusting relationships over time is important. Ideally this is done in such a way that an ongoing involvement of the knowledge brokers will become redundant. The facilitation of the relationship building is therefore a key task (Bielak, 2008) (see further information on deliberate network management in section 2.4.3 above). Good mediation skills are helpful for this. Folke (2005) suggests that not only can these knowledge brokers provide trust but also help to create trust. He notes that building trust is also correlated with investment in social capital. Investing well in someone who can create such social relationships, in can pay out to hire professional knowledge brokers. Various authors, e.g. De Vries et al., 2014; Gabarro, 1978; Gulati, 1995; Granovetter, 1985) suggest that trusting relationships evolve from social interactions and become stronger over time (Gabarro, 1978). Also Lacey at al. (2018) provided insights into how trust can developed over time.

In order for the research knowledge to be taken up and to achieve wider impact, knowledge brokers can make use of transitivity trust, which means that if one actor (or institution) is seen as trustworthy, people they trust will be trusted as well (Henry and Dietz, 2011). They can integrate other people who act as role models and/or have the ability that people from different spheres will listen, such as for example pop stars, actors and other influential people and celebrities. This has successfully been used in the international The Economics of Ecosystems and Biodiversity (TEEB) initiative[22], where for example Pavan Sukhdev, was appointed onto the advisory board and as spokesperson as he is/was well known and connected to and recognised by the studies target stakeholder groups. Currently he is named president, WWF-International and UNEP Goodwill Ambassador. Also the national project "Naturkapital Deutschland"[23], the national TEEB-study used this approach and included besides scientific experts for example Christian Schwägerl (journalist and author), Karsten Schwanke (TV moderator and meteorologist) and Dr. Antje von Dewitz (CEO of a big outdoor company) onto the projects advisory board. Long-term stakeholder strategies shall consider this concept of critical mass in their stakeholder strategy (see above in 2.3.2), so the maximal possible number of people can be reached and wider impact achieved.

Changes can occur at a range of time-scales, from short-term interventions (in which changes in values are typically small and limited to changes in contextual values, like preferences) to longer-term social learning processes, such as development of morals in children through education or modelling adult behaviour (Bandura, 1969; Bandura and Walters, 1977; Brody, 1978) or intergenerational and community based interactions that promote cultures with particular social norms, values and behaviours (Rist et al., 2003). Everard et al. (2016) argue that the values that people hold for the natural environment therefore are continuously shaped and moulded by social processes over time, depending on the cultures they are embedded in, and ways in which social interactions occur. Trust building is one key element and one that need resources and time to develop - time frames beyond temporary, short term projects (Berkes, 2009; Sandström et al., 2013). Cairney et al. (2016) point out that changes, e.g. in increased knowledge uptake and impact, might not occur immediate, but that it could take years to develop a critical mass that supports particular evidence-based policy solutions.

2.5.4 Merge research and policy cycles

Research and policy cycles/agendas seem to be more often than not separated from each other (Lövbrand, 2007). Some researchers critique the separation of the policy cycle in phases and state that the differentiation between policy formation and implementation is simplified and is not reflected in reality (Jann and Wegrich, 2007). The term policy cycle in this thesis shall thereby only

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[22] http://www.teebweb.org/ accessed 5 February 2019.
[23] http://www.naturkapital-teeb.de/en/news.html accessed 5 February 2019.

recognise that policies can be formed in certain ways, in particular pattern that can be seen as circular progress and that policy formation and research agendas are often separated then interlinked, as stated above. In any case, in order to effectively implement ecosystem service knowledge the time schedules/agendas of researchers and policy makers need to match up.

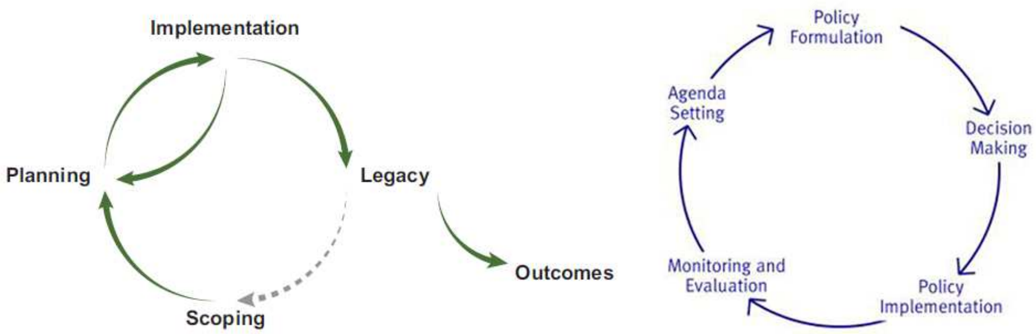

Figure 2. 1 Research cycle (left) and policy cycle (right) according to Andrews (2012).

According to Andrews (2012) a research cycle that matches up with policy agendas includes a scoping phase, where all stakeholders need to be involved and their needs analysed and prioritised. The planning phase is the proceeding phase where a detailed knowledge and adoption plans are produced, including the budget. In the implementation phase milestones according to the knowledge and adoption plans are met, reports are written, evaluations are done and updates pursued if necessary. This phase is followed up by the important but often neglected legacy phase in the last phase of the research project to evaluate and reflect on achievements and take action to ensure ongoing access to projects outputs. It is important to learn and adopt throughout the progress as it is a dynamic process.

The adaptive management literature emphasise the iterative nature of policy innovations as living experiments, from which policy-makers and researchers can learning by doing and consequently adapt policy accordingly to new lessons learnt during the process (Holling et al., 1998). Olsson et al. (2004) argue that in this way, adaptive management can increase the resilience of policy solutions by enhancing the capacity to deal with change and uncertainty over time, which in turn increases capacity to deal with future change. Self-organising science-policy networks have the capacity to co-generate knowledge and create functional feedback loops with numerous social links across spatial scales and policy domains (Van den Hove, 2007). Olsson et al. (2004) argue that it is this collaborative learning or “adaptive co-management” process that helps build resilient policy solutions. Kenter et al. (2015) take this further to argue that by representing local knowledge and values from relevant communities in the policy-making process, it is possible to enhance the resilience of policies by increasing their resonance with multiple communities and reducing the likelihood of public outcry or backlash.

For these reasons, the time it takes for a policy innovation based on research evidence to move from a niche into multiple policies can therefore vary widely. Research funders and universities increasingly provide funding to incentivise engagement with policy (Colglazier, 2016; Bayley and Phipps, 2019), however timings in the research cycle are mismatched with policy cycle timings, leading to time lags that can prevent findings being relevant for policy (Morris et al., 2011; Sanjari et al., 2014). There are also concerns that research funding and assessment pressures bias research activity towards prevailing policies and ideologies, rather than seeking to use evidence constructively in current policies (Machen, 2019). However, equipped with theoretical insights into the ways that policy innovations are adopted, researchers may be able to adapt their recommendations and communicate them in ways that significantly reduce the time taken to affect policy change. By identifying times in the policy cycle and/or windows of opportunity when evidence can be most effectively used to affect policy change, it is possible for researchers to work increasingly collaboratively with the policy community to co-produce policy innovations in response to the problems faced by governments. This is sometimes called open policy-making (Beveridge et al., 2000).

In turn, policy impacts are more likely if co-production takes place throughout a research project's life cycle (Olsson et al., 2004). The Global IPBES assessment (IPBES, 2019) (peatlands are mentioned in there too) and especially the IPBES assessment on pollinators (IPBES, 2016) has been pick up by policy makers and further stakeholders worldwide (e.g. Hughes and Vadrot, 2019), as both of these assessments, their focus and topic and coverage have been mandated and debated by international policy makers and the multi-disciplinary scientific expert panels, they had clear timelines and fulfilled several aspects of stakeholder engagement at the science-policy interface. This way it best links to the policy cycle, which so far remains rather separate from the research cycle in many instances. Furthermore, the more science and policy cycles merge and engagement increases, the more likely it is that a long-term, trusting relationship will develop between the two actor groups (De Vente, 2016; Reed et al., 2018). Both actor groups have their daily agenda, which is unlikely to be anywhere identical. So a first step is to be aware of this difference (Bielak, 2008), accept and respect this fact and be open and willing to find ways to merge the two agendas. To overcome the additional difference of language it is worth using additional knowledge broker expertise. Stakeholder facilitation can improve the alignment with each stakeholders personal and professional agenda further (Haines et al., 2004).

It is also important to note that stakeholder needs and priorities may change over time, and that certain stakeholders may have greater interest and/or influence at different points in the research and policy cycles. For this reason, Reed and Curzon (2015) emphasise the need to maintain stakeholder analysis as an ongoing, iterative process, to identify new stakeholders and changing needs and priorities as they become relevant. The precise timing for engagement is very target group specific and the daily working and life schedule of the target group should be considered in order to identify best windows of time to engage. Yet, the best time for engagement still remains anecdotal. However, it is known that knowledge brokers can help to facilitate stakeholder engagement processes, including the facilitation of an open discussion about expectations at any point of the co-production.

2.5.5 Frequency of communication

Frequency of communication is a widely used proxy for trust (e.g. Borgatti and Li, 2009; Levin and Cross, 2004; Prell, 2009; Tsai and Ghoshal, 1998). Hereby frequency of communication can be a proxy for trust, more frequent communication can also lead to more trust and increased knowledge exchange as these factors are in fact intertwined. Tsai and Ghoshal (1998) for example found that trust, as part of social capital, manifests itself and is stimulated in more social interactions which, in turn, leads to the exchange of more resources (including knowledge). As such, it is possible that trust can be both a pre-cursor to and an outcome of communication and knowledge exchange. From their analysis of interactions between government officials of the Investment Fund for Rural Areas (ILG) in the Netherlands, De Vries et al. (2014) emphasise the importance of frequent social interactions over time for the development of trust, as this provides more opportunities for participants to become acquainted with each other’s perceptions, and the underpinning values and beliefs that give rise to these perceptions. These values may change over time, and so influence the dynamics of interactions in the social networks in which people interact according to a study on social valuation of ecosystem services by Kenter et al. (2016). Also Lacey at al. (2018) provided insights into how trust developed over time. Ongoing communication is vital in the development of long-term trusting relationship leading to decision-making (Edelenbos and Klijn, 2007). Multiple publications on knowledge exchange and science-policy interfaces focussing on ecosystem services suggest the need for “regular”, “frequent” or “ongoing” communication (e.g. Cvitanovic et al., 2018; Durham et al., 2014; Edelenbos and Klijn, 2007; Young et al., 2013). If knowledge is repeatedly exchanged and refined through constructive dialogue the effectiveness for uptake increased according to findings from studying science-policy interfaces for biodiversity (Tinch et al., 2018). However, to be of practical use the issue regarding the precise frequency that leads to decision-making has yet to be addressed (see research results in chapter 3).

2.6 Spatial scales – Where is knowledge uptake taking place?

Environmental governance operates at local and within social scales, but increasingly at global scales via multi-lateral policy initiatives such as the Rio Conventions including Convention of Biological Diversity (CBD) and its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), Intergovernmental Panel on Climate Change (IPCC) or the United Nations Convention to Combat Desertification (UNCCD) Science-policy interface (SPI).

The previous section considered who could and should integrate scientific ecosystem service knowledge into environmental governance. In addition to considering the role of knowledge intermediaries (from individual actors to institutions), it is important to consider the social and physical spaces within which these actors and institutions are situated. Issues of scale are crucial for understanding how knowledge can be transferred, generated and used to govern ecosystem services, given the multiple spatial and temporal scales over which ecosystem processes operate. On one hand, this may be about scaling up governance solutions and institutional structures that operate successfully at local scales to affect change at broader spatial scales. On the other hand, this may be about managing these different approaches to governance at multiple, interacting scales, facilitating knowledge exchange and collaboration between local actors and institutions and structures that operate across scales. These might not necessarily respect administrative boundaries and create interfaces between informal and formal institutions.

2.6.1 Social scales and social networks

To achieve the integration of different forms of knowledge at different spatial and institutional scales, it is necessary to understand how knowledge is socially situated within the networks of individual actors who are affected by or who can affect environmental decision/governance. How these individual actors then self-organise (e.g. Ostrom, 2015) or are organised in formal and informal institutions may explain why some groups are able to mobilise ecosystem service evidence for decision-making more effectively than others, and how decision-makers find the evidence they use.

There is emphasis in the literature on the importance of social networks in ecosystem management and for dealing with uncertainty and change (e.g., Shannon, 1998, Wilson, 2002). Knowledge is socially situated and is therefore a vital foundation for knowledge exchange within social networks. Thereby social networks can act as informal institutions. In fact social networks can be more important than formal institutions (Bodin and Crona, 2009). Network structures can facilitate or hinder knowledge exchange, both in policy and funding contexts (Klijn, 2005). Establishing and maintaining social network structure can come with a cost (Granovetter, 1973) for example given the time it takes to organise joint meetings and develop a common language and goals (Ernstson et al., 2010). But once successful social network interactions within established patterns are established transaction costs are lower (Degenne and Forsé, 1999; Schneider et al., 2003). According to the adaptive governance literature, individual actors within social network are able to connect to overall polycentric governance structures (e.g. Folke et al., 2005; Cairney, 2019).

Theories of strong ties and weak ties by Granovetter (1973) point out the importance of the existence of both types of links for the spreading of information over greater distances in the network and in preparing the network actors as well as their formal and informal institutions for future innovations and adaptation to new situations. The presence of both strong and weak ties also ensures to break up homophilic group thinking (Granovetter, 1973). Also the transitions management literature focuses at societal scales, the scales at which ecosystem processes/services work and need to be managed (Foxon et al., 2009) and focusses on those who actually manages them (mainly local people) (Foxon, 2011; Heiskanen et al., 2009). Even though lots of environmental problem occur on larger scales, solutions can be found in local and individual scales (Mouratiadou and Moran, 2007).

Whether conceptualised as informal institutions, when organised in these ways, social networks can become empowered to engage in environmental governance. The adaptive management and adaptive co-management literature proposes a number of ways in which institutional change may be managed to protect and enhance ecosystem services. This literature is typically focussed at local scales, engaging local stakeholders in a “learning by doing” experimental approach to ecosystem service management (Folke et al., 2002; Armitage, 2005). Adaptive co-management can be seen as a co-operation between different bridging organisations that can work more efficiently to jointly solve these problems over time. Here the bridging of different actors, building trust, resolving conflict and networking play important roles by using both vertical as well as horizontal linkages between institutions (Berkes, 2009). Knowing the actors and their networking structure might help to improve adaptive co-management approaches.

It is important to link institutional structures from local to global scales, as all scales need to work together to enable effective environmental governance. These institutions need to be designed to allow for flexibility to adapt. In the transition management literature (Kemp et al., 2005) a need for both formal and informal institutions is recognised. Furthermore, it is useful to include a variety of institutional arrangements, including hierarchies, markets as well as self-governed communities (Henry and Dietz, 2011; Ostrom, 2015). Formal institutions supporting the dialogue between the scientific and policy arena include formally arranged national and international science-policy interfaces (SPIs) and informal institutions could be seen as general social networks based on individual social networks connections, based on trust. Managing and facilitating necessary institutional changes are therefore important for ecosystem service management.

To enable up to date research outcomes to get included in policy decisions an effective communication at the interface between biodiversity research and policy is necessary (Spierenburg, 2012). Hence national (e.g. Belgian[24], German[25], Swiss[26] biodiversity platforms), European (e.g. EPBRS[27] or EKLIPSE[28]) and international (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[29] science-policy interfaces (SPIs) for biodiversity as well as ecosystem services exist and operate to enhance the connection between the research and the policy world. However, Koetz et al. (2011) state that institutional arrangements such as SPIs may fail in the implementation of international environmental governance due to poor design of these institutions. This can be the case if they lack political as well as scientific legitimacy (Koetz et al., 2011). Koetz et al. (2011) continue that with the case of IPBES one of the initial problems was to adapt a stakeholder strategy or yet alone defining a stakeholder.

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[24] http://www.biodiversity.be/ accessed 2 February 2018.
[25] http://www.biodiversity.de/ accessed 2 February 2018.
[26] https://naturalsciences.ch/organisations/biodiversity accessed 2 February 2018.
[27] http://www.epbrs.org/ accessed 2 February 2018.
[28] http://www.eklipse-mechanism.eu accessed 2 February 2018.
[29] www.ipbes.net accessed 2 February 2018.

2.6.2 Physical scales and upscaling

Moving from mere social scales to more physical scales, one can consider ecological as well as hydrological scales. Physical multi-scales reach from entities smaller than the microscopic to landscape to global scale. They are physically situated and linked to ecosystem services and natural capital. The adaptive co-managements literature e.g. by Ernstson et al. (2010) and Folke et al. (2005) considers the term social-ecological system in order to describe the direct interaction between the social and the ecological scale and as a framework that combines ecological scales with social network structure. Yet open questions remain, especially if it comes to ideas to scale up solutions or how big can the social-ecological system be and still be successfully managed? The adaptive co-management literature usually focusses on local scales. This is useful to operationalise ecosystem service approach (Primmer and Furmann, 2012) and to solve environmental governance challenges at local levels. This requires and enables the involvement input from various actors (e.g. Van de Kerkhof and Wieczorek, 2005). Adaptive management approaches are therefore successfully applied to small-scale and well-defined resource systems (Johnson, 1999) and include social learning (Tompkins and Adgar, 2004). By scaling up ecological management to larger scales – for example national levels, national SPIs can be mentioned. Is there an option to upscale to global international scale? Effective governance mechanisms at these large scales are absent, but necessary for managing global commons (Dietz et al., 2003). According to Dietz et al. (2003), critical (environmental) problems occur on larger scale without local influence. The absence of effective governance institutions at appropriate scale lead to the so called tragedy of the commons (e.g. overfishing (Dietz et al., 2003, Ostrom et al., 1999). Thoughts on the governance of the commons still concludes with the need for active engagement of multiple local stakeholders.

2.7 Evaluation

Even though strategies to transfer research results exist, evidence of effectiveness of these are lacking, Panisset et al. (2012) and Fazey et al. (2014) therefore call for structured and coordinated evaluation of such interventions including environmental research projects addressing global environmental challenges. Evaluation and reflection practices are particular important in order to find best practice examples to upscale research evidence uptake, which has been identified as a major barrier to progress on international policy goals. Regular feedback and evaluation and adaption of the knowledge exchange and inclusive impact strategies are required (Fazey et al., 2014). This includes evaluation of the dissemination goals to ensure an effective and timely communication of research results (Mea et al., 2016). It needs to be evaluated if stakeholder groups have changed during the progress of the research project and whether or not they gained or lost interest in it and therefore their influence might have changed, which would require an adaption of the stakeholder engagement strategy. If the evaluation requires the system to change, action should be planned and followed accordingly.

Oliver et al. (2019) recommend to evaluate the chosen engagement strategy, but also point out the lack of time that is typically allocated for these reflection processes. The authors continue that co-production of knowledge includes potential risks to all stakeholders involved, therefore evaluation of these practices are important. Amongst the risks mentioned are that these interactions are time consuming, can lead to misunderstandings and conflicts, or the purpose might remain unclear or not be shared by all involved. Hence the goals of the research are unlikely able to reflect all values, beliefs or the priority of everyone involved. It takes time and organisational effort to get every stakeholder to attend meetings and experienced skilled facilitators to form and mediate the group dynamics, values, beliefs, priorities etc. Unsuccessful coproduction can lead to mistrust of scientists and science profession as such. Oliver et al. (2019) point out to be aware of the risk that the credibility and interdependence of the researcher could be questioned and need to be reflected on regularly.

However, given that some of the risks mentioned by the authors above also apply if no effort towards stakeholder engagement is made, they might be neglected. The remaining risks need to be approached with all the available evidence and enacted upon by skilled facilitator professionals to limit them as much as possible. The foremost and urgent reason for this is to speed up actions to halt biodiversity loss and combat climate change.

2.8 Conclusions

Results from the literature clearly show that the uptake of environmental knowledge is not a straightforward topic and getting the right conditions for successful knowledge exchange and uptake into decision-making requires further careful consideration. This chapter reviewed the current literature on uptake of ecosystem service knowledge within decision-making while identifying gaps that will be addressed within this PhD research. The chapter integrated multiple insights from theoretical frameworks and empirical published evidence to derive key design considerations for successful uptake of environmental knowledge for decision-making. The first section dealt with the need to design knowledge exchange strategies which includes the development and transparent communication and regular reflection of common goals which should be relevant, credible and legitimate. This is followed by a section addressing the representation of all relevant stakeholders, including the relevance of diffusion theory and potential for social network analysis for this process. It further elaborates the value of deliberate network management and facilitation of stakeholder management and engagement by professional skilled knowledge brokers. The third part described essential elements and theories for engagement of the chosen stakeholders, followed by two sections answering the question when and where this engagement should take place.

Based on the literature reviewed in this chapter, there are currently a number of insights into the role of evidence in policy decisions, but there is limited evidence on the applicability of these insights to ecosystem service related policy, or the relative importance of different factors influencing decision-making in this context, for example the environmental governance literature regularly reports “ongoing”, “frequent”, or “regular” exchange between actors involved in environmental decision-making contexts (e.g. Cvitanovic et al., 2018; Durham et al., 2014; Edelenbos and Klijn, 2007; Young et al., 2013). However, these terms are too vague to be of practical use to advise relevant stakeholders to adapt and improve their communication and impact strategies. However, further insights into these factors are important because ecosystem service knowledge is particularly complex as it links to multiple social and ecological systems. Ecosystem services knowledge furthermore informs a wide range of policy domains. In addition, peatland policy, the focus of this thesis, is a nascent policy area with only a few peatland policies or strategies worldwide and up to now limited empirical evidence exists about how these policies draw on evidence. These knowledge gaps are addressed with objective 1 of this thesis (see section 1.4. for details on the objectives).

The literature revealed a wide ranging critique of the linear model (e.g. Pielke, 2007). Therefore, it is worth testing the effect of linear transfer of knowledge versus two-way knowledge exchange while focussing both on the transfer as well as the reception of knowledge by the network actors. Especially the reception of knowledge has been scarcely covered in scientific literature up to date, hence an interesting factor to study within objective 2 and its research questions. A two-way dialogue and knowledge exchange between researchers, policy makers and further stakeholder is meant to be more suited to find solutions to safeguard the environment according to Koetz et al. (2011) and Young et al. (2014). To add further empirical evidence on this claim, this research therefore specifically analyses the strength of the connection between a two-way exchange and decision-making in a closed peatland science-policy network.

So far research literature has focussed more on evaluating knowledge exchange from the perspective of researchers, whereas the policy makers' perspectives on knowledge exchange at environmental science-policy interfaces is less well studied, yet alone the peatland science-policy interface. Therefore, objective 3 of this thesis aims to analyse policy makers' perceptions of successful knowledge exchange at the peatland science-policy interface.

As some recent applied research project deliverables (Durham et al, 2014) and publications (Reed et al., 2014) pointed out, research outputs shall be target specific and synthesised. As these are in an easy accessible format, readily useable and target audience specific, I formulate recommendations, as suggested by Durham et al. (2014) for stakeholders at the science-policy interface to exchange their knowledge successfully with the other relevant stakeholder groups, increasing the likelihood that their knowledge informs and is implemented in decision-making (objective 4).

With the identified gaps and the associated research objectives, this chapter therefore built a foundation for this PhD research, while staying open to further relevant and novel aspects of communication at the science-policy interface.

Chapter 3 – Research Design and Methodology

This chapter describes the mixed-methods research design employed in this PhD project, to answer the research questions. This combines qualitative and quantitative approaches in two main data collection phases, focussing first at national case study scale and then at international scale. The chapter explains how case studies have been selected and details the methods that were used to collect and analyse data in each case. Limitations and shortcomings of methods are discussed transparently and it is described how they were addressed.

After justifying the mixed-methods research design in section 3.1, the next parts of this chapter explain and describe each of the methods in more detail. Section 3.2 considers the choice of case studies. Section 3.3 describes how the stakeholder interviews were conducted and analysed via Social and Bayesian network analysis. The stakeholder workshop is described in section 3.4. How the questionnaire was planned and implemented in section 3.5.

3.1 Mixed-methods research design

The research takes a mixed-methods approach, combining stakeholder interviews, Social network Analysis (SNA), Bayesian Network analysis (BN), questionnaire and a focussed stakeholder workshop discussion to explore science-policy networks and network communication within peatland ecosystem case studies. The mix of quantitative and qualitative methods were selected and adopted to investigate the science-policy network in depth.

A critical realist approach underpins the choice of mixed methods and case studies for this research. This approach allowed for the generation of knowledge in multiple forms, which needed to be collected in different ways. Critical realists presume that there is a real world, however the understanding of this world cannot be proven nor disproven (Easton, 2010). Critical realism argues that it is possible to identify objectively knowable realities but that reality is an interaction between different human perceptions of those realities (Pawson, 2006). As a result, systems thinking is commonly adopted to explore complexity (e.g. Gharajedaghi, 2011) and recognise that interventions in a system may lead to uncertain, emergent and multiple outcomes (Rogers, 2008). For these reasons, this research adopted a mixed methods approach including quantitative as well as qualitative data collection and analyses that allowed for the generation of in-depth insights from stakeholders' individual perspectives. This required a broad theoretical foundation (see Chapter 2) from which relevant methods were combined and case studies selected as part of a coherent research design.

In order to study why things are the way they are, case studies are particularly suited to reflect the critical realistic philosophy (Easton, 2010). Although not intended to be representative or provide universal findings, case studies (see section 3.2), if well selected, allow a degree of analytical generalisation to similar contexts, and provide concrete benefits to research participants in their specific settings (Schofield, 1993; Yin, 2013). By investigating two peatland ecosystem case studies through stakeholder workshops and in-depth stakeholder interviews it was possible to study "science-policy communication" from the participants' viewpoint (Evely et al., 2008).

The mixed method approach utilised stakeholder interviews to feed into probabilistic graphical models (Bayesian Networks) and Social network analysis (SNA). This approach was chosen because neither a pure qualitative nor a pure quantitative design would be sufficient to capture the range and depth of material necessary to understand both the structure and function of social networks in knowledge exchange at the science-policy interface. The subjective nature of knowledge exchange as an individual and social learning process (Reed et al., 2010) requires in-depth qualitative data collection methods and an inductive approach to analysis that is not constrained by prior conceptions. The combination of quantitative and qualitative data collection and analysis also ensured a more comprehensive triangulation of results (e.g. Bryman, 2012).

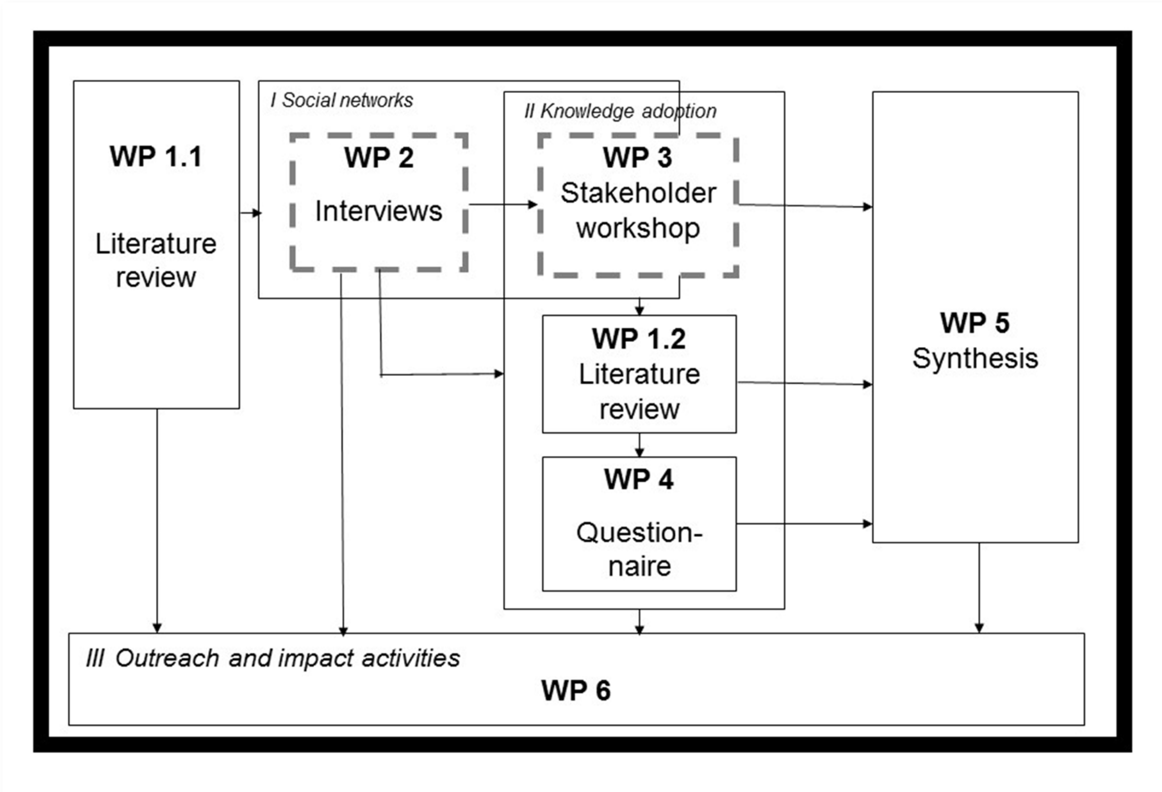

Figure 3. 1 PhD research design presented as work package framework giving an overview of methodological approaches taken.

Figure 3.1 shows the mixed-methods research design, consisting of five linked work packages (WPs 2 and 3 are both case study based, denoted by grey dashed box). These included:

- WP 1.1: initial literature review to refine research questions, research design and theoretical context for the research.

- WP 1.2: further literature review to identify and fill knowledge gaps based on existing research and interpret emerging research findings.

- WP 2: interviews were conducted with identified actors in the two selected peatland ecosystem service case studies.

- WP 3: a workshop conducted for the Peatland Code case study in which preliminary results were shown, followed by a moderated stakeholder discussion allowing reflections, hypotheses, questions and potential answers.

- WP 4: a questionnaire investigating science-policy dialogue from the perspective of international peatland policy makers.

- WP 5: triangulation and integration of all results from WP 1-4 into a concluding synthesis chapter.

- WP 6: an ongoing, targeted and continuous outreach strategy ensured a regular exchange with stakeholders to enable an increased likelihood for research uptake and impact.

3.2 Case studies

The research follows an exploratory case study approach. It compares findings from two national case studies to infer generalisable principles and develop new theory about the role of knowledge exchange in environmental governance. The study is conducted based on the evaluation of the Peatland Code[30] in the United Kingdom and the MoorFutures project[31] in Germany. The case studies have been selected based on fit with the topic of ecosystem services of peatlands. The peatland ecosystems focus was chosen as peatlands are under severe threat, for example through extensive agriculture and horticulture practices (Bain et al., 2011; Crump et al., 2017). Intact peatland ecosystems provide a wide range of ecosystem services ('public goods'), including extremely effective carbon storage abilities (e.g. Bonn et al., 2014 and 2016; Kimmel and Mander, 2010). Covering only 3% of the world's land and freshwater surface, peatlands store 30% of the global soil carbon. They therefore exceed the carbon pool of the world's forests and equal that of the atmosphere (e.g. Joosten and Clarke, 2002). Therefore, effective policy for peatland ecosystems plays an important role in global climate and biodiversity protection (Millennium Ecosystem Assessment, 2005; Parish et al., 2008) and directly address sustainable development goals (SDGs)[32].

Both peatland initiatives were developed to address the need to find alternative funding for peatland restoration, to ensure that peatlands can indeed play their important role in environmental protection. This is done via regional carbon markets, or so-called payment for ecosystem service schemes (PES schemes), as there is growing recognition that both public and private sectors can play a role in financing of ecosystem services that deliver 'public goods'. Both

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[30] http://www.iucn-uk-peatlandprogramme.org/peatland-code accessed on 18 March 2019.
[31] http://www.moorfutures.de/ accessed on 18 March 2019.
[32] https://www.un.org/sustainabledevelopment/climate-change/ accessed on 26 May 2020.

case study projects have an underlying mechanism to ensure that buyers of ecosystem services are guaranteed measurable ecosystem service outcomes. Both case studies comprise transdisciplinary networks including a diverse stakeholder composition of experts from the natural and social sciences, policy and land management practitioner communities, and business and carbon market consultants (Bonn et al., 2014). The breath of this stakeholder engagement made the research particular interesting. As a new policy area, these PES networks are co-producing new policy together, providing an opportunity to examine these networks during live policy processes. Similarities between these case studies enable comparison of the network structures between them. This provides insights that are of practical relevance for peatland policy that can then be generalised for application to other habitats and geo-political contexts. For further justification of the peatland focus of this research see section 1.3.

3.2.1 Peatland Code

The Peatland Code is a voluntary standard for UK peatland projects, which aims to restore peatland ecosystems and therefore benefits the climate and provides further ecosystem services (Reed et al., 2013). The Executive Board of the Peatland Code is facilitated by IUCN UK Peatland Programme staff with headquarters in Edinburgh and is supported by an active Technical Advisory Board made of members from all over the UK and including various stakeholders such as scientists, water companies, policy makers and NGOs, who provide technical oversight and recommendations to the Peatland Code Executive Board. The Peatland Code itself provides the specific principles, requirements and guidance for monitoring of participating projects. This is validated by an independent body assuring customers receive verifiable climate benefits over the project peatland restoration project.

The Peatland Code project started in 2013 with projects in England, Wales and under the Scottish Government's Peatland Action programme. It was formally launched in 2015 with the Peatland Code version 1.0. After stakeholder discussions and in alignment with the protocol for greenhouse gas project accounting the Peatland Code version 1.1 was launched 2017 and builds the verification standard for all current and future Peatland Code projects.

3.2.2 MoorFutures

In contrast to the nationally operating Peatland Code, MoorFutures is a regional peatland-based carbon offset initiative that also aims to raise funds for peatland restoration (Bonn et al., 2014) on the voluntary carbon market. Inspired by the successful carbon storing forest restoration project (Waldaktie), the Ministry for Agriculture and the Environment of Mecklenburg-Vorpommern (MLUV), Germany, launched MoorFutures in 2010 (Berghöfer et al., 2011). Its carbon credits were the first issued for peatland rewetting in the world (MLUV, 2009) and inspired the development of the Peatland Code.

The MoorFutures project network involves scientists, policy makers, a communication specialist and actors from agencies responsible for selling the MoorFutures product. Initially carbon credits were only sold by the Ministry (MLUV), initiator of the programme. The price of one MoorFutures is calculated per avoided tCO_2-equivalent (Berghöfer et al., 2011). Currently MoorFutures credits are also sold by two other federal states (Brandenburg since 2012 and Schleswig-Holstein since 2014). Further states and other countries are interested in applying this successful brand and methodology both within and outside of Germany. The MoorFutures standard has been developed based on the Verified Carbon Standard (VCS) Wetland Restoration and Conservation (WRC) guidance (Bonn et al., 2014) and adjusted to suit specific regional ecosystem conditions. MoorFutures uses proxies to estimate emission reductions called greenhouse gas emission site types or the GEST approach. MoorFutures uses a forward looking baseline that is being compared with a reference scenario that would have occurred without successful completion of the peatland restoration project. They give a guarantee to save carbon over 50 years. Over 10,000 credits have been sold so far. MoorFutures 2.0 and 3.0 versions have been developed to integrate further ecosystem services including biodiversity protection and nutrient retention (Joosten et al., 2013a).

3.2.3 Reasoning for case study approach

Case study approaches provide benefits as well as limitations. They involve an intense study of a single unit (e.g. Gerring, 2004). Yin (2009) suggests, if the chosen research questions include 'how' or 'why', to use a case study or field experiment approach. Case studies are now frequently used in social science. Given my research questions (see 2.2 above), a case study design therefore seemed the logical choice.

The choice of case studies is important. Case study approaches are meant to be illustrative rather than representative. They allow for the intense study of an entire communication network system (Gerring, 2004). According to Bryman (2012) "sampling by context" involves purposively, rather than randomly, selecting cases that are relevant to the research objectives (see 1.4.). This approach enables the analysis of similarities (here, similarities and shared lessons between two payment for ecosystem services schemes concerning peatlands) and differences (here, the differences between the two schemes' communication networks, actor selection and geographic location). Case studies allowed for the collection of multiple sources of evidence and an in-depth analysis of the heterogenic elements of the chosen cases. The case study approach furthermore allowed for the necessary flexibility to use multiple methodological tools, some of which enabled interactions with and between participants to uncover underlying processes of communication. Flyvbjerg (2006) continues that a strength of this approach is that it is able to both build and test theories (George et al., 2005). This is relevant for this research as the case study approach was designed to apply existing theories linked to diffusion theory (Rogers, 2003), structural holes (Burt, 2009) and strong and weak ties (Granovetter, 1977, 1983) deductively, whilst allowing for inductive development of new theory.

Case studies are characterised as "small-n" studies (George et al., 2002). While some scientists state, that a study with n=2 is unlikely to be representative and may risk selection bias (Flyvbjerg, 2006), George et al. (2005) argues that generalisation should not be made on the basis of case studies due to their context specificity, and so qualitative understanding rather than representativeness is the goal. Case studies are useful to explore complex causality and to develop theories (George et al., 2005). One of the strengths of case study research is the ability to use a combination of inductive and deductive coding of the material that allows to derive new hypothesis and consequently new theory (George et al., 2005). Each case study provides a huge number of intervening variables enabling a better identification of complex causal relations (e.g. George et al., 2005; Ragin, 2014). Given these potential shortcomings of the use of case studies and their potential limited ability to generalise, these issues are further embedded and discussed transparently in the relevant discussion parts of chapters in this thesis.

In conclusion each of the two chosen case studies is unique as they are the first two blended finance mechanisms designed to combine public and private funding for the protection of peatlands in the world, and have unique integration of researchers, policy makers and other stakeholders in a live policy co-production context.

To collect and analyse data in the case studies, the following methods were used: stakeholder interviews analysed via Social network analysis, Bayesian network analysis, followed by a stakeholder workshop and an international targeted questionnaire. Detailed method descriptions related to work packages 2, 3 and 4 (Figure 3.1) can be found below.

3.3 Stakeholder interviews and Social and Bayesian network analyses

3.3.1 Interview structure and approach

Stakeholder interviews formed the foundation of data collection and input into both social network (see 3.3.3) and Bayesian network (see 3.3.4) analyses. They were piloted in May 2015 and adapted specifically to reduce the length to a minimum. 20 stakeholders involved in the Peatland Code case study projects were identified because of their involvement as members of the Peatland Code board and 14 MoorFutures stakeholders were identified with support of the MoorFutures coordinator. The ethical approval for this research was granted by Newcastle University on 19 September 2016. All 34 stakeholders were contacted via email for an appointment for an interview. Several reminders were sent out to some participants. The first Peatland Code interview was trialled in February 2017. Eight Peatland Code interviews were conducted in person in Stanhope, Newcastle and Edinburgh, UK in April 2017 and one MoorFutures interview in Edale, UK in September 2017. Where face-to-face interview were not possible, interviews were held via Skype or phone. Two stakeholders per case study could not be interviewed. 18 interviews for the Peatland Code and 12 for the MoorFutures case study were audio recorded.

Bryman (2012) considers stakeholder interviews an appropriate tool as they allow for cross-case comparability. The overall focus for the interviews were aimed to find answers based on themes that emerged from an initial literature review, based around the following questions:

- How are case study actors linked through knowledge exchange activities relating to peatlands ecosystem service knowledge?
- What is the relative importance of factors facilitating knowledge exchange to increase the likelihood for decision-making in science-policy networks?
- Who are the necessary network actors and what are their roles within the network?
- Who is responsible to set-up, maintain and facilitate the desired network structure?
- What do successful network structures look like?
- How and through whom does knowledge currently reach policy makers?

An interview schedule was used to guide the interviewees. Previous set questions, in originally 3 parts, were used to structure the interview. At the start of the interview each participant was thanked for their willingness to take part and a background and purpose of the PhD project was presented. This was followed by an explanation of the overall structure of the interview and time allowed to ask (clarifying) questions. The overall structure of the interviews consisted of three parts:

(1) First, summarising knowledge about ecosystem services.
(2) Followed by investigating the personal network connection within the Peatland Code and MoorFutures.
(3) Finally, exploring some further details about these network links.

Before continuing, all interviewees were asked for permission to audio-record the interview. Consent was given in all cases.

In the first part of the interviews, participants were ask to name examples of peatland ecosystem services. The reason for this was firstly to break the ice and secondly to set the basis for the remaining questions of the interview, as the network connections are defined in relation to an exchange of knowledge of ecosystem services of peatlands.

The second part of the structured interview was intended to derive quantitative information. The data was used to derive a matrix of all personal network connections each interviewee had within their case study. This in turn enabled me to produce a communication network for each of the case studies. An example from preliminary results of a communication network from pilot interviews were shown to the participants. It was explained that each individual map will be combined to enable anonymity. It was explained that with the help of social network analysis such network maps are able to identify strengths and weaknesses of the network, in order to point to possibilities to strengthen efforts to improve the network's activities and science-policy interface communication. For the data collection itself, a list was prepared of all people who are on the Peatland Code Board and the MoorFutures network. The answers to the following questions were recorded in an excel table:

- Have you provided ecosystem service knowledge to this person in the past 12 months?
- Have you received ecosystem service knowledge from this person in the past 12 months?
- Have you been in an active dialogue about ecosystem service knowledge with this person in the past 12 months? (As the latter refers to a two way rather than one way communication)

Once interviewees were asked about their network connections within the identified case study network boundary, participants were asked if they would like to add anyone else outside their case study that they felt was essential in terms of knowledge exchange of ecosystem knowledge. If participants added names, additional data was collected using the same questions as above.

The purpose of the third part of the interview was to provide insights into the relative importance of factors facilitating knowledge exchange and whether or not they helped to inform individual decision-making. The resulting data fed into a Bayesian network analysis which is described below. The order of questions are as follows and the reasoning behind each of these is stated after the question:

- How long have you known this person in years? The length of relationship was used as a proxy for trust[33] and the strength of network ties.
- How often do you normally communicate with this person? Potential answers were: weekly, monthly, quarterly, twice a year, once a year, and no communication. The frequency of communication was also used as a proxy for trust[33] and the strength of network ties.
- Which of the options in the box apply to the means by which you communicate with this person? Potential answers were: in person, via email, via phone and others could be added. The mode of communication and potentially preferred way of communication lead to the hypothesis: Do more direct communication connections lead to more trust and increased knowledge exchange?
- Which of the options in the box best describes how useful your exchange and communication with this person is/has been? Potential answers were: very useful, useful, slightly useful, of no use, not relevant, of no use and had a negative impact. The effectiveness of exchange was used as a proxy for increased knowledge uptake.

[33] *Frequency of communication* is a widely used proxy for trust (e.g. Levin and Cross, 2004). However, the factors are in fact intertwined. Tsai and Ghoshal (1998) found that trust, as part of social capital, manifests itself and is stimulated in more social interactions which, in turn, leads to the exchange of more resources (including knowledge). As such, it is possible that trust can be both a pre-cursor to and an outcome of communication and knowledge exchange. Despite the tautological nature of this question, it is possible to sub-divide this into these two separate questions and examine the role of trust (frequency of communication as a proxy) in knowledge exchange whilst also examining how knowledge exchange might influence trust through the qualitative research accompanying the Baysian network.

- Have you used the ecosystem service knowledge you have received and/or exchanged with this person for your decisions yet? The effectiveness of exchange was also used as a proxy for increased knowledge uptake.

After analysis of preliminary results of Peatland Code interview data, a specifying question was added to the remaining MoorFutures interviews regarding the type of decisions that were made based on the communication with other stakeholders in the network. To compensate for not having asked this question to previous interviewees, I contacted them separately to ask for an additional interview in order to collect more insights of the character and types of decisions being made amongst the members of the Peatland Code. The additional follow-up questions were used to gain more detailed response from the interviewee about the initially stated decision they made based on the communication with other network actors.

Interviews concluded with thanks, an opportunity for the interviewee to ask questions, a re-iteration of the need to receive signed consent forms and an explanation of next steps in the research, including what they could expect to receive in future from the project, based on the findings of the research. The qualitative data collected through the interviews were analysed to find repeating themes and the analytical approach is described below.

3.3.2 Qualitative data analysis

The combination of quantitative (Social and Bayesian Network analyses) and qualitative data collection ensured a more comprehensive triangulation of results, increasing both the rigour and depth of analysis (e.g. see similar approaches used by Johnson and Onwuegbuzie, 2004 and Reed et al., 2018). Qualitative techniques were used to analyse open-ended answers and other comments in stakeholder interviews that could not be analysed using SNA or Bayesian networks. If the methodological aim is to capture the complexities of a qualitative data content, thematic analysis is the most useful data analysis techniques according to Guest et al. (2012). It does not focus on counting words or phrases, but on identifying and describing themes (Säynäjoki et al., 2014). Open and axial coding helped to unearth underlying themes and patterns that may not have emerged from the data via more deductive methods e.g. content analysis or thematic analysis looking for *a priori* themes.

The qualitative data from the case study therefore included information gathered during the stakeholder interviews, derived from answers to open-ended questions and everything else that was being said by the interviewees beyond the questions requiring only quantitative answer. The data was also analysed together with data generated from the stakeholder workshop discussion (see section 3.4) and data from the questionnaire of international policy makers (see section 3.5). The qualitative data was partially transcribed as sentences and phrases. Open coding was done sentence by sentence or phrase by phrase by assigning names, themes and categories to the text using excel sheets. Several themes could emerge from any one sentence or phrase. This resulted in a long list of codes, which were grouped into preliminary categories. Axial coding then proceeded by relating themes from the open coding to each other to look for integrative themes, patterns and theories via a combination of inductive and deductive thinking. Inductive generation of theory during this process sought to intuitively link emerging themes as they arose from the interview transcripts. Inductive coding was necessary to capture any new emerging themes underlying the qualitative data. Deductive axial coding was based on existing theory from the literature and interpretations of data that had arisen from stakeholder workshop participants during the Peatland Code stakeholder workshop. Coding was done to the point of saturation of themes, where no new themes emerged (Rivas, 2012). Using this method themes "progressively" emerged over the coding process. The resulting meta-themes and theory that emerged from this analysis are described in the result sections of the data chapters 4, 5 and 6.

3.3.3 Social network analysis

Quantitative analysis of the interviews used social network analysis parameters and a Bayesian network approach. Social network data from these interviews were used to explore and visualise the network structure of the selected case studies. Results were interpreted with theories such as diffusion theory (Rogers, 2003), structural holes (Burt, 2009) and strength of the weak ties (Granovetter, 1977, 1983) (more on these theories above in section 2.3.2). Results helped to identify and discuss how knowledge was diffused in the case study networks, the different roles of each actor and to analyse who is responsible for setting up, maintaining and facilitating the network structure (e.g. Crona and Bodin, 2006; Prell, 2012; Sandström et al., 2013). Furthermore, central and peripheral actors were identified for each network.

Social networks focus on relationships between social actors who may be connected to one another in a wide variety of ways, often within a certain scope or boundary (e.g. within an institution, project or community). In this research, the focus of the networks was on communication and decision-making relationships amongst actors of two case study networks, defined by the institutional constructs of the official bodies operating the Peatland Code and MoorFutures. Wasserman and Faust (1994) introduce Social network analysis (SNA) as a distinct research perspective which uses clear defined parameters to analyse the given social structure properties expressed in mathematical statements. SNA is mainly used in social and behaviour science, marketing and economics (Wasserman and Faust, 1994), as well as in studies applying diffusion of innovations theory (Rogers, 2003) and environmental governance (Prell, 2012; Bodin and Prell, 2011). There is empirical evidence about the effects of network structures on how actors behave in natural resource governance (Bodin and Crona, 2009); on the resilience of the network (Booher and Innes, 2010; Lebel et al., 2006); on trust building (Henry and Dietz, 2011) and the networks performance (Sandström and Carlsson, 2008). In this study, SNA is used to gain in depth insights into the chosen case studies' communication network relational links and factors that facilitate or hinder flows of knowledge through a network. This is important to get a better understanding of why evidence-informed decision making works or does not work, not just in qualitative terms, but also on a quantitative basis.

In this research study, "actors" are defined as individuals within each case study. For the Peatland Code case study, 20 actors were identified prior to the interviews according to their appointment as administrational or technical advisory board members. 14 actors were identified for the MoorFutures project together with the support of the project manager. SNA data was gathered through stakeholder interviews as described above. In total, five different "edge" types, in other words the connections between network actors, were identified through interviews: 1) who knows each other; 2) who transferred knowledge about ecosystem services from peatlands to whom in the network; 3) from whom in the network do actors receive knowledge about ecosystem services of peatlands; 4) with whom are actors in an active dialogue about ecosystem services knowledge of peatlands; and 5) based on the communication with whom in the network were decisions made or not.

The resulting networks were analysed and visualised for each case study. For this binary data was entered into matrices in excel spreadsheets and then visualised and analysed with the help of the program UCINET (Borgatti et al., 2002). The parameters analysed were in and outdegree and betweenness centrality. Indegree centrality is the number of ties (directed edges) received by an actor from others in the network (e.g. Prell, 2012). Outdegree centrality is the number of ties (directed edges) this actor has to other actors in the network (e.g. (Prell, 2012). Betweenness centrality considers the position of actors in a network and calculates how many times each of them is positioned on the shortest path connection between two other actors in the network (Prell, 2012). Data of all interviews were combined to result in one of five networks for each case study relation.

The five social networks are analysed and visualised for each case study. Relationships within the networks are represented by “nodes” and “edges”. Each “node” represents an “actor” and “edges” represents the existing (communicative or decision-making) connection between these actors. The five different network analyses were each chosen for separate reasons. The first network analysis sought to show who knew who in each network. Starting with the network that analyses who knows who in the network and followed by the networks that analyse the transfer and perceived reception of knowledge. The reasons for the second (knowledge transfer), third (knowledge reception) and forth (dialogue) networks were aligned with the objectives of this study to explore knowledge exchange network structure to find evidence for underlying successful structural elements. The fourth network looks into two-way knowledge exchange and whether or not participants had a dialogue with each other, whilst the fifth and final network represents connections between actors who made decisions based on their communication with each other. The fifth network considered the impact of successful knowledge exchange. Was the knowledge exchange indeed “good” enough to lead to decisions being made or not?

3.3.4 Bayesian network analysis

A Bayesian network analysis was added to the method portfolio due to its strengths in computing probabilities and visualising scenarios[34] (e.g. Marcot, 2017). It therefore enhances the results of the quantitative information from stakeholder interviews and gives insights into the parameters that are important and relevant for decisions being made between two people in the case study networks.

Whereas social network analysis and qualitative methods show and explain how knowledge is flowing through the networks and tell us about the role of the network structure, including the

[34] *Scenarios* are different (potential) combinations of variables that reflect possible world-views or states. By making use of conditional probability tables in the BNs, potential states that have not occurred in the dataset can be explored, as conditional dependencies are inferred from the model. (Marcot, 2017).

position of certain types of actor in the network and the roles they play, neither method can clarify the relative importance of different key factors in the decision-making process. This was identified as a gap in the literature (see literature review in chapter 2) and is needed in order to isolate the most critical factors determining evidence into policy. Relevant actors responsible for contributing research to policy can therefore focus their limited resources on the most relevant factors that were identified with this research (see chapter 5 for results). Combined with a qualitative analysis of stakeholder interviews, this mixed-method approach enhances and triangulates the results and gives insights into the parameters of importance and relevance for decisions being made between two people in a social network. Whereas the Bayesian network models explore different scenarios that focus on factors enabling or disabling science-policy communication over time, the qualitative data explores and explains these results in more depth. The Bayesian approach enables an assessment of relative importance of factors influencing decision-making in the network. Such in-depth analyses of knowledge uptake and decision-making of case studies have been rarely done, but they are able to provide empirically grounded guidance for effective science-policy processes (Reed et al., 2018). The results of the Bayesian network scenarios provide evidence for the optimal frequencies and modes of communication to enable knowledge uptake and decision-making over time. Moreover, results of this research provide evidence into the questions of when and how trust is formed and developed over the duration of the relationships. It also sheds light onto the factors necessary to build long-term relationships that improve decision-making.

What is a Bayesian Network?

Stephenson (2000) describes Bayesian networks (BN) as a combination of graph theory and probability theory. Bayesian networks are directed acyclic graphs (Neapolitan, 2003). This means that these graphs consisting of nodes and edges (sometimes called arcs), edges are always directed and do not form cycles. Each of the nodes represent a variable. Edges represent conditional dependencies between variables. Under different scenarios, the probability of the state of each variable is calculated by updating each of these conditional dependencies. Differing from social networks, nodes do not represent people or groups of people, but represent variables and edges and show conditional dependencies, instead of relationships between people, as in social networks. BNs are graphical models supporting the visualisation of variables representing the problem in question (see chapter 5 for an example derived from this research).

Other types of graphical models that are similar or the same as Bayesian networks are called (Bayesian) belief network, causal networks, (probabilistic) independence networks, and Markov fields (Stephenson, 2000). There are an increasing number of publications on Bayesian network modelling covering various disciplines (Marcot, 2017). Application fields include automatic speech recognition and medical diagnosis; where observed symptoms are included into the Bayesian network and the different probabilities for different diseases are computed that could best match the provided symptoms (Stephenson, 2000). More closely related to this study are Bayesian applications for climate change research (Moe et al., 2016), examining trade-offs among ecosystem services (Landuyt et al., 2016), predicting food webs and trophic relationships for fisheries (Trifonova et al., 2015, 2017), predicting deforestation (Mayfield et al., 2017) and addressing uncertainty in conservation decision-making, due to unclear conservation status of species (Bolam, 2018).

Relevance of Bayesian Networks analysis

BNs have potential as a decision-support tool (Stewart et al., 2013) while working with a wide range of stakeholders (Landuyt et al., 2013) as they allow for "live" scenarios in stakeholder meetings. One of the key advantages of BNs is that machine learnt models are easy and quick to build via freely available open source programmes (e.g. the GeNIe Modeler (Bayes Fusion LLC, 2017), which is used in this study), and provide highly intuitive interfaces (Marcot, 2017). As it is easy to test different scenarios (e.g. model trade-offs) and assumptions (Marcot, 2017) with these visual models, they are easier to interpret than statistical models, as they display probabilities. The visual provision of probabilities makes Bayesian network models very transparent. For example Campbell et al. (2012) constructed a BN using expert and stakeholder knowledge and datasets from the Western Indian Ocean and appreciated it as a user friendly tool. The BN helped them to visually communicate, the main impacts of implementing a marine policy on Marine Protected Area on the environmental, economic and social impacts to fishery dependent communities, to marine policymakers and planners.

BN was chosen due to its ability to provide useful insights in contexts where some data is uncertain or incomplete, as was the case in the networks of decision-makers studies (e.g. see Barton et al. (2012) and Hamilton et al. (2015) for BN applications that deal with uncertain data). Missing data points can be inputed for every variable. Also, a wide variety of data sources can inform a single model. Very few methods can deal well with uncertainties. BNs are useful for dealing with uncertainty because the probability distribution of variables can be displayed and the impact of changes in variables can be assessed transparently through scenario analysis. BNs can be used for predictive modelling, and predictions can be displayed alongside their associated probabilities, hence they are a useful tool for conservation decision making (Marcot et al., 2006). BNs have been applied to group model building (e.g. Henriksen et al., 2012) and to study decision-making (e.g. Barton et al., 2012) in environmental governance contexts not dissimilar to the kind of contexts found in the case studies used in this research.

Even though BNs are intuitive, this in itself can be problematic according to Niedermayer (2008), as a Bayesian network is only as useful as the prior knowledge – that it is fed with - is reliable. McDonald et al. (2015), who used BN in an aquatic ecology context found that the limitation with the method, is in connection with the inability to develop feedback loops that occur in their study system and to include these into their BN model structures. However, they found ways to overcome this provide solutions to minimize the challenges and limitations for development and use of BNs for their purpose. Multiple authors (e.g. Barton, 2012) mentioned the acyclic nature of the BN as a limitation, but found ways to minimise its effects. This combined with a few further, very technical problems around constructing and interpreting BN models remain also, but these can be dealt with according to a paper by Marcot (2017).

As a result, there are many applications of BNs for decision analysis in adaptive management (such as both chosen case studies), as these are complex systems. To sum up, BN analysis is a well-established approach. It is therefore an appropriate method for my study. BN and qualitative data analysis as a mixed-method approach, helps triangulate and so further strengthens the rigour of the findings of this research.

How were the Bayesian networks models constructed and analysed?

The Bayesian network models are based on quantitative data from interviewing 30 stakeholders from the two case studies in the UK and Germany (see above). Unfortunately, I was not able to conduct the BN analysis in the workshop setting, which was originally planned. The quantitative data from the stakeholder interviews were entered in an excel table. If the data were not binary, they were allocated to categories (for example for node 5, 6 and 8). The dataset was then imported into the Bayesian Network software GeNIe Modeler (Bayes Fusion LLC, 2017) to analyse the Bayesian networks.

Originally, two networks were created. First, an unsupervised network was computed. Unsupervised networks (Scutari and Denis, 2014) are machine-learnt networks (MLBN) that use algorithms allowing the construction of BNs based on data alone. This allows patterns from the data to determine the BN structure and the conditional dependencies rather than relying on those structures proposed by experts or the researcher as the case in supervised networks (Scutari and Denis, 2014).

Second, a supervised Bayesian belief network (BBN) was computed, based on the logic of the researcher derived from findings from the literature and preliminary qualitative analysis of interview and focus group data (e.g. Landuyt et al., 2013). After checking the resulting baseline scenarios of the Bayesian belief network (BBN) approach versus the machine learnt Bayesian network (MLBN) computed by the GeNIe Modeler (Bayes Fusion LLC, 2017) and comparing it to the original interview data, the decision was made to continue working with the MLBN for further analysis as it best represented the original data. The "greedy thick thinning classifier algorithm" was applied to the dataset with the Bayesian Network software GeNIe Modeler (Bayes Fusion LLC, 2017). Furthermore, the case studies were checked how distinct they were and based on their differences is was decided to analyse each of them in separate scenarios (see Appendix A-C – setting 0 versus 100 probability).

The final dataset contained the following 11 variables, which are expressed as network nodes. The choice for each node is justified with current literature:

- Node 1 – states whether or not the person is from either of the two case studies - Peatland Code or MoorFutures, mentioned by the interviewee as being an additional relevant person from outside the predetermined closed networks. It is important to understand exactly which actors in the network knew each other (Prell, 2012; Reed et al., 2009), as this might then explain some of the dynamics between group members.
- Node 2 – contains binary data (yes = 1 or no = 0) on knowledge transfer and is based on the answers to the question: Have you provided/transferred ecosystem service knowledge from peatlands (or further relevant knowledge) to this person in the past 12 months? Multiple studies have found relationships between effective knowledge transfer and trust (Andrews and Delahay, 2000, Penley and Hawkins, 1985, Tsai and Ghoshal, 1998, Zand 1972). However, if the linear model is criticised in the literature (e.g. Pielke, 2007), it is worth testing the effect of linear transfer of knowledge versus two-way knowledge exchange.
- Node 3 – contains binary data (yes = 1 or no = 0) based on the interviewees answer to the question: Have you received ecosystem service knowledge from peatlands (or further relevant knowledge) from this person in the past 12 months? The reception of knowledge

has been scarcely covered in scientific literature up to date, hence an interesting factor to study.

- Node 4 – contains binary data (yes = 1 or no = 0) based on the interviewees answer to the question: Have you been in a dialogue about ecosystem service knowledge from peatlands (or further relevant knowledge) - a 2-way rather than 1-way communication with this person in the past 12 months? A two-way dialogue and knowledge exchange between researchers, policy makers and further stakeholder might be more suited to find solutions to safeguard the environment (Koetz et al., 2011; Young et al., 2014). Therefore, the strength of the connection between a two-way exchange and decision-making has been analysed.
- Node 5 – states the length of relationship based on the question: How long have you known this person in years? Answers were than categorised (does not know the person = <0, less than a year = <=1, >1-5 years, >5-10 years, >10<20 years, >20 years). Various authors (e.g. De Vries et al., 2014; Gabarro, 1978; Gulati, 1995; Granovetter, 1985) suggest that trusting relationships evolve from social interactions and become stronger over time (Gabarro, 1978). Ongoing communication is vital in the development of long-term trusting relationships leading to decision-making (Edelenbos and Klijn, 2007). Also Lacey at al. (2018) provided insights into how trust developed over time, arguing that “too much” trust can develop in particularly long-term relationships between members of policy networks, which can lead to complacency rather than critically assessing the evidence provided by these contacts. As the length of relationship, social interaction, including ongoing communication (see node 6 below) is an established proxy for trust development, the intention of this research was to see if trust development over time is reflected in a potential increased likelihood of decision-making.
- Node 6 – states the frequency of communication based on the question: How often have you communicated with this person on average in the past year? Weekly, monthly, quarterly, twice a year, once a year, no communication). The environmental governance literature regularly reports “ongoing”, “frequent”, or “regular” exchange between actors involved in environmental decision-making contexts (e.g. Cvitanovic et al., 2018; Durham et al., 2014; Edelenbos and Klijn, 2007; Young et al., 2013), furthermore to create trustworthiness repetitive, ongoing interactions are required, according to Chang et al. (2010) published in cognitive psychology literature. However, these terms are too vague to be of practical use to advise relevant stakeholders to adapt and improve their communication and impact strategies. BN provided an opportunity to analyse frequency

of communication between decision-makers in-depth, based on the data derived from the case studies. Furthermore, frequency of communication is another well-established proxy for trust, presented through the strength of the tie connections and centrality measures.

- Nodes 7 a-c state binary data regarding the mode of communication based on the question: Which of the options in the box best describes the means by which you communicate with this person? Email, per phone and/or in person or are you also using other modes of communication? The literature usually talks about regular exchange, but is furthermore unclear or vague about the way or media of the exchange, hence the research explored these three options. Note: Zoom was not widely in use at the time of data collection.
- Node 8 – refers to answers by the interviewee regarding their perceived usefulness of the communication based on the question: Which of the options in the box best describes how useful your general communication with this person has been/is? Very useful, useful, slightly useful, of no use, not relevant or of no use and had a negative impact. Usefulness has been used to refer to relevance and credibility as part of the Credibility, relevance and legitimacy (CRELE) concept. These are also seen as key prerequisites for successful science-policy interactions (Farrell et al., 2006) and need to be considered and planned for from the outset. However, these widely used criteria can be difficult for the evaluation of the success of science-policy interfaces (Heink et al., 2015) (see section 2.2. in the thesis). Therefore the analysis of usefulness as a factor with a BN analysis is an attempt to see if this factor is helpful for further evaluation of successful stakeholder interactions.
- Node 9 – contains binary data (yes = 1 or no = 0) based on the question: Have you made a decision/decisions based on the communication you had with this person? The goal with this question was to find out what factors maximise likelihood for decision-making. However, it is also interesting to explore the factors and combination of factors that did not.

Different scenarios allowed the calculation of probabilities of the states of each node, by updating each of the conditional dependencies (represented by the edges in the network). Scenarios were chosen to find the ideal scenario with highest probability of decision making based on the given dataset and to answer the following questions derived from the research questions: How to best maximise the probability of decision making (over time)? Should stakeholders communicate in person or via email or phone? At what point of the development of the relationship between scientists, policy makers and practitioners is knowledge taken up, trust formed (discussing Lacey et al., 2018), and finally decisions being made? What is the relative importance of these factors to increase the probability for decision-making in science-policy networks? To address these questions, the following scenarios have been tested and analysed:

- Scenario 1: 100% decision probability scenario to find the optimal combination of factors to enable decision-making based on the communication between actors in each case study network.
- Scenario 2a – The influence of the length of relationship on the probability of decision-making - in order to see if the length of the relationship influences the probability for evidence-informed decision-making.
- Scenario 2b – Optimal scenario for each year category: this scenario combines the previous two (scenario 1 and scenario 2a). 100% probability targets are set both on the length of relationship node and on the decision node, in order to find out what factors change and how it changes if 100% decisions are made over the duration of the relationships (year categories).
- Scenario 3 – Influence of the frequency of communication on decision-making – these scenarios explore how the frequency of communication affect evidence-informed decisions being made.
- Scenario 4 – Influence of perceived usefulness of the communication on decision-making
- Scenarios 5a-c - Influence of the modes of communication on decision-making – to explore how does mode of communication influence that decisions are more likely? 5a in person, 5b via phone and 5c via email.
- Scenarios 6a-e. Influence of receiving and transferring knowledge versus engaging in a personal two-way knowledge exchange on decision making.
- Scenarios 6a-c explore the influence of the decision probability, if (6a) knowledge is only transferred, (6b) knowledge is only perceived to be received by the participant and (6c) only exchanged via a two-way dialogue with a target scenario of 100% probability for each of the three options. Scenarios 6d and 6e aim to analyse the consequences of an absence of two way knowledge exchange on the probability of decisions being made, if knowledge is only transferred (6d) or knowledge is only being received (6e).
- Scenario 7 – Comparing case study results with results from people who were mentioned from outside of the case study networks.

Limitations in connection with the application of the BN technique are discussed in section 5.4. The analysis of qualitative data collected during the case study interviews was used to interpret the results of the BN analysis in even further detail (see section 3.3.2 above).

3.4 Stakeholder workshop

One stakeholder workshop for the Peatland Code case study was held to seek feedback from stakeholders about the preliminary results derived from the social network and Bayesian network analyses. The purpose of stakeholder discussion was to draw upon the participants' perspectives and experiences of how to enhance the science-policy dialogue and the effectiveness of the communication network, to triangulate findings and inform the interpretation of results. It brought together an inclusive set of peatland governance stakeholders and enabled interactive discussions.

The stakeholder workshop drew on focus group methods. Focus group discussions allow to collect qualitative data through a planned structured discussion amongst stakeholders, facilitated by a skilled moderator and facilitator (Morgan, 1996; Scott, 2011; Waas et al., 2010). According to Scott (2011) focus groups normally consists of 6-15 participants. As 21 stakeholders participated in this workshop, it is distinguished by calling it a stakeholder workshop discussion instead. This larger group was dealt with by having another experienced co-facilitator and structured elicitation exercises to ensure good active listening, discourse and handling power dynamics, which have been shown to be important in delivering successful outcomes from stakeholder workshops (de Vente et al., 2016). Focus groups and larger workshops are frequently used in applied research (e.g. McCrum et al., 2009; Wilkinson, 1998), including in environmental research and policy (e.g. Burgess, 1996; Davies, 1999; Kline and Wichelns, 1996). This is also due to new governance agendas calling for deliberative and participative approaches (Scott, 2011).

The discussion is focussed on a predetermined topic (Morgan, 1996; Powell et al., 1996) and participants collectively react and interact with each other as a group (Kitzinger, 1994; Scott, 2011). This allows participants to explain the reasoning behind their thinking (Kitzinger, 1994). The interactions therefore may provide researchers with in-depth insights and sometimes unexpected findings (Skop, 2006). Provocation and open questions might be used carefully to develop a discourse (Derkzen and Boch, 2009; Scott, 2011). Focussed group stakeholder discussions require a skilled moderation and facilitation (De Vente et al., 2016). The essential skills of the workshop moderator and co-facilitator include foremost good active listening skills, where they paraphrase what has been said, clarify and confirm, if it was correctly understood. A skilled and experienced moderator ensures enhanced interaction and an equal chance for participants to contribute (Säynäjoki et al., 2014). Empathy is an important foundation for this (Markiewicz, 2005). Furthermore, good preparation of the workshop together with co-facilitator is needed. This enables optimal guidance of workshop discussions and reflection, and therefore collection of qualitative data on lessons learnt and shared experiences.

Justification of the stakeholder workshop methodology

As focus groups are designed to obtain information about people's reaction regarding specific topics, together with their ideas and values, they can generate new ideas (Huge et al., 2016) and hypotheses. Focus groups are furthermore useful to uncover attitudes, perceptions and beliefs (Skop, 2006). The method allows people to theorise their own point of view in relation to the presented data and to the other stakeholders' perspectives (Kitzinger, 1994). They allow for social learning via discussion and reflections (Marjolein and Rijkens-Klomp, 2002; Bull et al., 2008; McCrum et al., 2009). Furthermore, according to Scott (2011) focus groups can have multiple purposes ranging from exploratory, explanatory and participative to deliberative tools.

However, focus groups are still seen as controversial research tools. Some criticise them due to a lack of statistical validity, perceived subjectivity (Merton et al., 1990; Scott, 2011) and lack of established guidance for data analysis and interpretation (Massey, 2011). Furthermore, issues regarding group dynamics, empowerment and inclusivity usually occur and need to be addressed appropriately (Hemingway, 2012; Scott, 2011). Good moderation skills are essential to minimise facilitation biases and are crucial to the overall outcome of the discussion (Scott, 2011). As there are only a limited number of participants there are limitations of focussed group discussions in terms of their ability to generalise results derived from the qualitative data analysis (Scott, 2011).

Given the constraints of this method, the stakeholder discussion was used as a complementary methodology, to improve triangulation (Bullen et al., 1998) and not as an isolated tool (Scott, 2011). As I am a trained mediator, I am well-equipped with active listening skills to facilitate discussions, ensure active and equal participation, and deal with issues such as potential power dynamics.

Workshop description and data collection

The workshop for the Peatland Code case study took place as part of the Bogfest 2017 in Edale, UK on 21 September 2017 with stakeholders present from the Peatland Code. The conference was jointly organised by the IUCN UK peatland programme. The stakeholder workshop focussed and sought to collect participants' perspectives and experiences on how to enhance the science-policy dialogue and the effectiveness of the communication network. Hence, the objective of the workshops were:

- Reflection on the effectiveness of the network communication;
- Reflection and discussion of different roles of different positions in the network: peripherally versus centrally positioned actors.

At the start of the workshop, sign-in sheets were made available to record the name and organisation of participants and asked for their permission for use of data, to record and quote anonymously from the event. 21 people participated in the workshop, including five participants that were previously interviewed and are part of the Peatland Code case study network. All gave permission to use the data, audio record the event and quote anonymously. The structured and focussed workshop discussion was moderated by myself and co-facilitated by Prof Mark Reed.

The workshop commenced with a brief background of the study, the title of my PhD, the interview set-up and the questions that were asked in interviews. This was followed by a presentation of preliminary results. The 5 networks that resulted from a social network analysis looking at 18 out of 20 Peatland Code interviews were presented: 1. network of all personal connections; 2. network of one-way knowledge transfer, 3. network of perceived one-way reception of knowledge; 4. Two-way dialogue network and 5. A dialogue network with all connections where interviewees stated they made decisions based on the communication they had with other network actors. Furthermore, results from the optimal Bayesian network analysis scenario were presented (see chapter 5).

After the presentation finished, participants were invited to reflect on the following questions:

- What are your first thoughts?
- Do the network maps align with your personal image? Why/Why not?

This opened up the discussion for the workshop group to react, reflect and ask clarifying questions on the presented data. Participants were addressed with the following focus questions about lessons learnt:

- What works?
- What factors influenced that decisions (positive or negative) are made?
- What level of trust is needed for successful knowledge exchange?

After focussed discussions on these questions, stakeholders were encouraged to focus on positions and roles via the following questions:

- Can you identify who is a knowledge broker/ intermediary within the network?
- And why are these people so effective?
- What roles do people in peripheral positions play?
- Were the right people chosen for the Peatland Code board? Who is missing?/Who is too much? Why?

In the final part of the workshop, each participant was handed sticky notes and pens to write down what they wanted to do as their next communication steps. Results were collected on a flipchart sheet. The workshop lasted for 85 minutes. The stakeholder group discussion was audio recorded. After the workshop, the first emerging themes and hypotheses were noted down from memory from the workshop discussion. The recording was transcribed and analysed thematically and triangulated with results from the other analyses.

3.5 Questionnaire

A questionnaire was added to the multi-method mix in order to shed light onto successful knowledge exchange and trust development at the peatland science-policy interface from policy makers' perspectives. Policy makers' perspectives on knowledge exchange at the science-policy interface are not well studied. However, to ensure that we advance in measures for effective and efficient knowledge exchange and are able to ensure that scientific knowledge is indeed considered in the decision-making process, this information is vital. The questionnaire would also play a valuable role in the research by enabling the triangulation of previous collected data from interviews and stakeholder workshop discussions to further understand why people are motivated and how are they stimulated in order to engage in knowledge exchange.

Justification of the use of a questionnaire in the study

There are several advantages in the use of standardised web-based questionnaires. Electronic distribution allows to reach out to participants from a large geographic, global, international coverage without huge additional costs for time and travel. Questionnaires involve potentially less interviewer bias and can create greater anonymity amongst their responses, especially if personal and sensitive information are sought Bryman, 2012).

As with other methods, questionnaires have some disadvantages. First, questions need to be short and the questionnaire should not take much time to complete, so the length of questionnaire is an important factor for a good response rate. The lack of an interviewer may also mean potential misunderstandings cannot be clarified. A good pilot phase is therefore important. At the same time, it is important to discuss reasons and consequences of the effects of people who receive the questionnaire, but do not respond. Compared to personal interviews, there is a tendency for low questionnaire response rates. As this could bias the study due to not being representative, action should be taken to address this aspect. One way is to address this is by using measures to increase the motivation of respondents to take part. This can be done by sending out emails including all relevant information such as which university, who else is involved in the study, and who supports the study. Transparency enhances credibility and additionally reminder emails and/or follow-up postings can be send out. A good questionnaire layout and appearance is important and a good pilot pre-testing can limit or eliminate problems beforehand. One further aspect to ensure good return rates is the timing. According to an expert advice and in line with my experiences with social media use, Thursday afternoon and Friday are good times.

Questionnaire method description

During the initial literature review it became clear that more studies focussed on the scientific viewpoint of knowledge exchange. The target group for the questionnaire were therefore international policy makers that are responsible for peatlands. International policy makers were defined as working for international policy organisations (e.g. national Governments and UN agencies) and were identified via key informants with extensive experience working in peatland policy networks, and web searches aiming to identify Ramsar CEPA National Focal Points, UNFCCC Focal Points and REDD+ policy contacts. Based on this stakeholder list, the questionnaire was distributed to 650 contact addresses from international policy makers. All of collected policy makers that were identified were contacted.

In a next step research questions from previous WPs provided the basis for the development of questions for the questionnaire. This resulted in 11 questions, including six closed answer questions and five open-ended questions. They were designed first with general questions to clarify whether they are policy makers that make or made decisions on peatland ecosystems, what country they are from, and what institution they are working for. The detailed questions aimed to triangulate and enrich the results of this research from a policy makers' perspective. The resulting questionnaire questions were:

- Q1 Are you (or have you been) responsible for policies regarding peatland ecosystems? (Yes/No)
- Q2 What country are you from?
- Q3 What institution are you working for?
- Q4 Is the context of your work related to peatlands … (local, national, international, else)?
- Q5 Where do you get your knowledge from, that you base your decisions on? (Scientists, Policy makers, Public, Media, Colleagues in your institution, Family, Friends, Others)
- Q6 Please describe a recent decision you have made, based on communication you had with a researcher/researchers?
- Q7 Thinking about the example in the previous question - What was most useful in the communication with the researcher(s) from your perspective?
- Q8 Thinking about the example in the previous question - What was least useful in the communication with the researcher(s) from your perspective?
- Q9 How frequently do you interact with this researcher? (it was the first contact, weekly, monthly, quarterly, twice a year, once a year, Other (please specify))
- Q10 Please describe an interaction with a researcher/researchers that has decreased or increased (or both) your trust in research?
- Q11 Could you tell me the top three pieces of advice you would give to researchers communicating with you or who you are communicating evidence with? (what do you find useful/not useful in communicating with researchers?, what do you find effective or not and why?)

The questionnaire was trialled with four members of the IUCN UK Peatland Programme, and amended based on their feedback prior to being sent to the collected email list. They indicated that a questionnaire length >10 minutes may seriously compromise response rates from the selected target group. Therefore, the questionnaire was designed and trialled to ensure it could be done in less than 10 minutes and this information was integrated into the introduction text of the questionnaire, as well as stating it transparently in the email invitation.

The concept of transitivity trust was used to enhance response rates. Transitivity trust means that if one actor is seen as trustworthy, people they trust will be trusted too (Henry and Dietz, 2011). In practice, this meant that Hans Joosten's name was mentioned as one of the sources of contacts, helping to increase the credibility of the questionnaire and the research behind it. Within a successful invitation, a win-win can be initiated, with both parties working towards a common aim to protect peatlands and improve the knowledge exchange. The potential questionnaire respondents were offered a final report of the research. At the end of the questionnaire, participants were also encouraged to spread the word through their personal networks in order to motivate their peers and/or provide me with further contacts amongst other international peatland policy makers.

Survey Monkey software was chosen for the questionnaire. Piloting was done in May 2018 and minor adjustments were made. The final online questionnaire was distributed to 650 contact addresses from international policy makers, defined as working for international policy organisations (e.g. national Governments and UN agencies) via email, including an invitation and a web link to the questionnaire. In order to increase the likelihood of responses, the questionnaire was sent at the end of a working week - Thursday and Friday afternoons, depending on the time zone of the targeted policy-maker. A follow-up email was sent a week later, as a reminder and with a fixed deadline for responses. The received datasets were analysed further using qualitative data analysis (see 3.3.2 above).

3.6 Methodological limitations

Factors for the quantitative analyses were chosen on the basis of a narrative review of relevant literature. While this was not a systematic review, and not exhaustive, each of the factors identified have a strong evidence-base (see section 3.3.4).

Furthermore, it was not possible to analyse power dynamics or group decision-making processes in any detail using Bayesian Networks. However, betweenness centrality measures from the SNA give insights on who holds power to diffuse knowledge or not and therefore hold power (Bodin and Crona, 2009; Prell, 2012; Schiffer and Hauck, 2010) (see section 4.4.2.). Additional strength of the chosen mix-method comes in, as these aspects were also covered in the additional qualitative material about power and group decision-making in section 4.2.2.

Even though proxies for trust are well established in some current fields of study, the interpretation of the trust data might still be viewed with caution.

Finally a limitation regarding the questionnaire method used: Worldwide only a very limited number of policy makers exist who deal with peatlands. Even though 650 questionnaires were sent out, based on the busy work schedule of the target group only a small response rate could be achieved. This also led to very brief answers that were often very difficult to put into the required context or not at all. Consequently, the limited response rate did not allow for statistical analysis. However, the emerging themes were able to triangulate and enrich the data and results from previous chapters.

3.7 Conclusion

This chapter described the unique chosen mix-method approach consisting of qualitative and quantitative methods, which enabled an in-depth analysis and triangulation of results to derive recommendations on how to improve knowledge exchange at the science-policy interface.

Chapter 4 - Science-policy network structures for successful knowledge exchange and evidence-informed decision-making

4.1 Introduction

This chapter explores how the structures of social networks influence the success of knowledge exchange and evidence-informed decision-making. The structure of the networks involved in science-policy knowledge exchange is investigated. Research has shown that network structures themselves are able to improve environmental governance and facilitation of network development (Bodin and Crona, 2009). Social network analysis is a valuable technique to study these structures in science-policy and other stakeholder contexts (e.g. Best and Holmes, 2010; Prell et al., 2009; Reed et al., 2018). Bodin and Crona (2009) for example analysed empirically literature on structural characteristics of social networks in natural resource management settings and showed that significant variations in governing outcomes can occur in relation to structural differences in terms of density[35] of network relationships, degree of cohesiveness, subgroup interconnectivity and degree of network centralisation. Cvitanovics et al. (2017) similarly used social network analysis to analyse an environmental case study in Australia and found that over time this network increased in density and cohesiveness, which was seen as foundation for successful knowledge exchange. Furthermore, Prell and colleagues intensively used social network analysis to study multiple natural resource management cases (e.g. Prell et al., 2008; Prell et al., 2009; Prell et al., 2010; Prell, 2012). The relational structures and positions of actors within networks play crucial roles in the circulation of knowledge (Dowd et al., 2014; Cunningham et al., 2015; Cvitanovic et al., 2017). According to Fischer and Jasny (2017) social capital theory refers to network actors being positioned in the network to build trust and a mutual understanding of relevant problems. In this position they are able to exchange knowledge and resources and collectively address these problems at stake. Individual node attributes, such as in and outdegree

[35] *Density* is the proportion of possible ties in a network that are actually present. It measures to what extent actors in a network are tied to one another (e.g. Prell, 2009; Wasserman and Faust, 1994).

centrality and betweenness centrality, are able to shed light into the location of individuals and their roles within the communication networks.

There is a need for evaluation of evidence-informed decision-making processes in social networks as they are a crucial foundation for successful environmental policies. Currently evaluations of evidence-based knowledge exchange are lacking (Mitton et al., 2007; Fazey et al., 2014; Reed et al., 2018). Despite the key role of knowledge exchange in networks, theories of social networks have barely been applied in in-depth studies of knowledge transfer and implementation of biodiversity and ecosystem service knowledge at the science-policy interface (Reed et al., 2018).

But how does the network structure and the knowledge exchange connections in science-policy interfaces matter for decision-making and consequently for the integration of peatland ecosystem service knowledge in conservation policy? And what network structure connections are required to allow for good communication linkages and build resilient social networks at the science-policy interface?

The chapters' objective is to address the above questions and therefore provide the following:

- Description of the social network structure of the actors in each of the two selected case studies from the United Kingdom and Germany
- Analysis of how these actors are linked through knowledge exchange activities relating to peatlands ecosystem service knowledge by identifying specific pathways through which knowledge has been transferred, received and exchanged via dialogue
- Analysis and discussion of which knowledge exchanges led to decision-making and exploring how this process is supported or hindered by the network structure
- Visualisation of the resulting networks
- Analysis and discussion of the central versus periphery position of the actors and their roles within networks
- Discussion of the development of centrality in the network for the success knowledge exchange and uptake over time

The research objectives are addressed with an in-depth analysis of the case studies' knowledge exchange and decision-making networks using social network analysis (SNA) (Borgatti et al., 2002; Prell, 2012; Reed et al., 2018), structured interviews and an analysis of a stakeholder workshop discussion. Both case studies focus on peatland ecosystems service and are chosen as they can answer useful and important questions about science-policy dialogue, as both case studies are unique payment for peatland ecosystem services mechanisms in the world and present a rare integration of researchers and policy makers in a live policy co-production context. In and outdegree, betweenness centrality measures are analysed to determine centrally and peripherally positioned actors, weak and strong ties and actors covering structural holes (e.g. Prell, 2012). Social network analysis results are triangulated with qualitative data that provide insights into the network structure and positions of actors within both networks which in turn sheds light on their role in getting peatland ecosystem service research evidence into policy. Results provide empirically grounded evidence for effective science-policy knowledge exchange and decision-making processes. Results may enable the network actors to reflect on their current communication activities and support future changes.

4.2 What knowledge is exchanged, taken up and considered for what decisions?

The aim of the thesis is to study the uptake of peatland ecosystem service knowledge for decision-making. As this chapter explores how the structures of social networks influence the success of knowledge exchange and evidence-informed decision-making, it needs to be clear what knowledge has been exchanged that led to decisions amongst the interviewed network actors. Therefore, the interview started with the request for the participants to summarise their knowledge about ecosystem services. This is important as the following questions and network knowledge exchange connections needed to be based and focussed on this knowledge. All questions focussed on peatland ecosystem service knowledge that had been transferred/received and/or exchanged during the 12 months prior to the interview. See more on this and the interview questions listed in section 3.3.1.

4.2.1 Peatland ecosystem knowledge

Some peatland ecosystem functions and services were already introduced in section 1.1 in the introduction to this thesis. These included: recreational and educational opportunities, income through tourism, water purification (Kimmel and Mander, 2010), water regulation, regulation of micro and macro climate, provision of food, raw material, medical plants, storage of historic/archaeological knowledge and drinking water (Joosten and Clarke, 2002). The majority of interviews only briefly mentioned these broad peatland services during this introductory part of the interview. However, qualitative material from the participants furthermore revealed additional, not yet published, peatland ecosystem services. These included recreational services provided by a clear night sky (P2[36], who works as a practioner in a remote peatland area in the UK) and peatlands religious/spiritual services, as in the past peatlands were used to "store and bury dead people. We have a burying in some peatlands near the coast. We find there gold and bronze and bracelets." (M2). Further qualitative material revealed additional details about peatland ecosystem services and functions. These include: the attenuation of weather and precipitation extremes (M9 and M12). For P5, a policy officer, carbon sequestration and the emission reduction opportunities are particularly valuable benefits to people. M11 pointed out the peatland ecosystems'' filtering functions in the landscape, combined with groundwater storage and water purification (also highlighted by M9 and others). For example M6 specified and mentioned that functional peatland ecosystems support the: "retention of particular pesticides and the phosphorus and nitrate inputs from agricultural practices", which is otherwise "coming into rivers and ending up in the Baltic Sea." (M5). M5 explained by saying that measurements of these services have shown a strong effect and this "is cheaper than building water purification plants. And it helps us to keep the Baltic Sea clean – a promise that we made together with the HELCOM countries." M11 furthermore emphasised the archive value of peatlands by saying: "What is very special about peatlands - they store information that they have sequestered and stored over thousands, over millennia. They can give us a lot of information about the past landscape and the past conditions in the landscape." M9, the communications spokesperson of MoorFutures goes into various details about the peatland ecosystem services that are easy to communicate and often visualise, which helps other stakeholders including lay people to understand their immense values and "to open their heart and head". M9 said the filtering of water, as mentioned above, functions well for communication, as is the use of flagship species such as sundew (*Drosera*) (Maiz-Tome, 2016), bog frog (*Rana arvalis*) (Kuzmin et. al., 2009), short-eared owl (*Asio flammeus*) and cotton grass (*Eriophorum spec.*) to highlight the biological diversity.

Even though the focus of knowledge exchange network connections were recalibrated to and emphasized to be on peatland ecosystem services, there was a tendency to extend the focus and include other aspects and other information too.

[36] Please find further information about all MoorFutures actors (always starting with "M") in section 4.3.1 and all Peatland Code actors (always starting with a "P" in section 4.3.2. below respectively.

4.2.2 What decisions were made based on the exchanged knowledge?

Thirty interviews revealed 573 individual communication connections between the case study actors within and beyond the two case studies. Amongst these network connections, in 234 connections, one decision or more were being made, based on the communication people have had with each other. To briefly recap the definition of "decision-maker" and "decision-making" used for this thesis: In contrast with multiple authors, who equate decision-makers to policy decision-makers, all of the actors that are included in the case studies for this thesis are defined as decision-makers regardless of their profession. Although some were policy-makers, others were not members of the policy community, but instead were part of the policy networks linked to the two case study initiatives (see Heclo and King (1978) for a definition of a policy network). This inclusion derives from the following definition: "Decision making is one of the basic cognitive processes of human behaviors by which a preferred option or a course of actions is chosen from among a set of alternatives based on certain criteria." according to Wang and Ruhe (2007, p. 1) and can occur every few seconds, both consciously or subconsciously (see chapter 1, section 1.2).

If an interviewee stated that he/she made a decision based on the communication with other stakeholders in the network, a specifying question was added to the interviews regarding the type of decisions that were made (see Method Chapter 3 section 3.3.1.). Answers varied: some interviewees revealed more or less information about the decision they made. Some only put their decisions in overall decision categories, for example administrative, strategic, research or structural decisions. Analysing the decisions that were made, it became clear that some emerging themes overlap. Four overarching theme categories can be distinguished: decisions based on structure, roles and power in the network constellation; the role of trust for decision-making, including decisions related to personal traits; categorised decisions: strategic, administrative and research decisions; and group decision-making versus decisions made in a dyadic relationship. Representative quotes will highlight each of these theme categories.

1) Decisions based on structure, roles and power in the network

The decisions participants made were based on or influenced by structural issues and related consequences. This included consequences of certain positions that actors hold in the network and/or hierarchical structure, which led to the related power that came with these network constellations. Participants described that they sometimes made decisions based on what their boss or the trademark owner said:

"[P7, Director of the IUCN UK Peatland Programme] is my boss. So essentially I make a lot of decisions based on what [P7] [says]. Primarily more to do with which projects or what businesses we approach with regards promoting ES […]. And quite a lot about the admission factors […]."

[P8, the Peatland Code manager]

Well, [M12] is the owner of the trademark. I decide everything that is relevant for MoorFutures with [M12]. […] I discuss every step with [M12] that has external effects [e.g. flyer, website, certificates, …]."

[M9, communications spokesperson]

Further decisions were made as roles in the network changed and knowledge needed to be transferred to build a foundation for informed decision-making. For example:

"[P1, researcher] lead on the Peatland Code before I started. So some of the first decisions I made were influenced by [P1] and a general transfer of knowledge from [P1]' time working on the Code. […] Decisions on how we market the ecosystem services. [P1]' research on layering and bundleing of ecosystem services."

[P8, the Peatland Code manager]

The following quote describes a further structural requirement for decisions as mentioned by M7 [scientist], based on the realisation that the further development and extension of the MoorFutures project required advanced structures, split into the administrative and the research advisory board.

"The thing is, that with MoorFutures, we realised that we now have three different states involved, that we now need an own structure [for decisions]. And now there is the administrative level and the research advisory board."

[M7, scientist]

2) The role of trust in decision-making

This section is divided into sub-themes on types of trust: personal versus organisational trust – e.g. one person trusts the person for who they are or basis of trust is based e.g. on their competence and expertise, including based on their history; or trusts them because they trust their organisation, (Rust et al., 2020).

Decisions related to personal trust:

Decisions can be based on the competencies and expertises of the other network actors. Therefore, the other network actors are asked for advice, for example, based on the depth of knowledge, expertise or length of experience. The illustrative quote below describes how M5 [researcher] works with M1 [researcher and political negotiator] based on M1 competencies, expertise, role and also trust. It describes in detail how these two actors work very closely together – while M1 attends meetings (UNFCCC COP meetings) as a national negotiator of Belarus, the other [M5] researches the topics that come up live in the negotiations and require urgent, scientific-evidence, back home in Germany, making use of the different time-zone. This enabled them to feed in the relevant needed knowledge for the necessary political decisions, communicating it at the right time, while making full use of their different roles and related competencies and legitimate roles as both researchers and policy-makers:

> *"[M1] was a representative for Belarus and then he/she was in closed negotiations and he/she Skyped me and said: 'There is a guy here, that says this and that, can you find it out?' M1 knew from the meetings what the problem was and we could react. And so I did an analysis during the night, I went into the internet and did all kinds of stuff or I knew it already, because I have a lot of data already on my computer. And I would say – this is correct or here, this is wrong or should think about that and he/she could bring that science or that knowledge into the negotiations. I made interpretations and made graphs and that we could send to Kuala Lumpur, Malaysia and that we could bring to the table and say this is the science and this is why we need to make a decision in this or that direction. We also did that during the negotiations and the UNFCCC. I did the science and he/she did the policy. So you can convince the world with science. But you have to have the right people to communicate it. And the right way of communicating it. And the right timing, yes."*
>
> [M5, scientist]

Similarly, the following participant in the PC network described a trusting relationship based on a long history, where a decision was made to choose a specific study site.

> *"We have a lot of trust, because [… confidential]. I chose his/her site as one of the two sites that we are now studying in the Peatland Code project. He/she has a history of being very helpful. Very reliable."*
>
> [P1, researcher]

P8 [Peatland Code manager] also valued P14`S [chair] historical knowledge in connection with his/her role in the network:

> *"But [P14] is quite a significant figure in the group, so his/her input is always very valid. [Why?]: He/she has lots of historical information […]"*
>
> [P8, Peatland Code manager]

P1 shared how he/she valued P7's feedback and intelligence that he/she fed into his/her decision-making process that ultimatiately led to good outcomes:

"I made decisions based on feedback or intelligence I gained from [P7] that has informed my networking and my research. And most importantly my impact, I would argue. His/her insights about opportunities that I have then taken up."

[P1, researcher]

Interviewee M5 talked about the process and speed of his/her decision-making in relation to knowledge exchange with M1:

"It is more like, slowly minor shifts that happen, that you would not say – yes, because I talked with him/her that I made my decision or that I changed my view of these things work. Within this close network, at least for my, for where I am, this communication is very often and we are on a similar level and we often have the same idea at the same time."

[M5, researcher about M1, researcher and political negotiator]

Whereas P8 [Peatland Code manager] received knowledge that helped him/her to put his/her decisions in different scale contexts from regional to global. Consequently P8 also made decisions on who to reach out to, to into their networks:

"[P4, Advisor on carbon standards, techniques and infrastructure] has experiences with the Woodland Carbon Code and accounting principles. Also in a global context. How we validate and verify ecosystem service provision? More technical things […]."

[P8, Peatland Code manager]

"He/she has given input on … global perspective/overview, links to companies like the Yorkshire water etc. So, I made decisions on which kind of companies we should try to attract … He/she has opinion it should be large scale and stick within other frameworks, so keeps us focussed on a good UK context. He/she is keeping us in the UK agenda."

[P8, Peatland Code manager based on communication with an external actor from outside of the Peatland code network]

P1 [researcher on the Peatland Code executive board] pointed out a decision he/she made that led P1 to receive funding for peatland research, which was based on trusting the additional expertise and knowledge that P18 [researcher] holds:

"[P18] has helped me to get research funding and do better research. He/she was extremely important in enabling us to get a project. I came to him/her with – which turned out to be a very naïve idea – […]. We were able to build something far more sophisticated, that actually got through the NERC research … Without his/her help I wouldn't have been able to make decisions to radically change the proposal compared to how it was originally pitched."

[P1, researcher]

Various network actors mentioned different topical decisions, including decisions they made based on exchange about e.g. ecosystem services, including cultural services. For example M11 made decisions based on knowledge exchange about natural capital and ecosystem services with an external actor. M11 pointed out that their knowledge exchange impacts his/her work, especially as he/she is aware of the need to extend work [research] on cultural ecosystem services:

> *"I talked with him/her about natural capital and ecosystem services, about projectories. My work is influenced by these conversations. Also there is work to do about cultural ecosystem services."*
>
> [M11, scientist]

Furthermore, P8 made decisions based in knowledge he/she received from P18, a scientist. This helped him/her to quantify ecosystem services, specifically in connection to greenhouse gas emissions:

> *"P18 is in a research role. […] good information on emission factors […]. Decision on quantifying ecosystem services that we make upon information from P18."*
>
> [P8, Peatland Code manager]

Similarly, P10, who represents interests from across the water utilities sector and advises the Peatland Code network on tactical issues, valued P11's practical expertise and made decisions based on knowledge exchange with him/her:

> *"[Decisions are based on …] understanding peatland restoration methods and techniques and learning from what he/she has done and also sharing this experience back. He/she is a good peatland manager to ask."*
>
> [P10, representative for interests from across the water utilities sector]

Decisions related to organisational trust:

Some decisions are made as the interviewees trust a personal, especially with their organisational background knowledge attached.

For example P8 valued and trusted P13`s opinions based on his/her expertise and experience with landowners in connection to his/her affiliation to the British National Farmers' Union (NFU):

> *"[P13] works at NFU. His/her collective view of the opinion of the landowners and what they are looking for has been very good for my decisions about opportunity costs and how we go about [grazing … integrated with other land uses]."*
>
> [P8, Peatland Code manager]

This is in line with P7, who specifically asks for, trusts and implements P14`s knowledge and experience from the business sector, e.g. on what further sectors and what individuals to include in the network to promote the Peatland Code product:

> *"Sometimes asking for thoughts on the types of individuals that we should be using or working with in promoting the Peatland Code. So I am using his experience as has worked in business."*
> [P7, Director of the IUCN UK Peatland Programme in relation to P14, chair]

P8, the Peatland Code manager, in turn, mentioned decisions he/she made on communication with P10. P10 works as a researcher for a water company and studies impact of peatland restoration on water quality and how this effects the water sector. P8 trusted these research results and made decisions to first focus on carbon for the development of the Peatland Code:

> *"[P10] works for a water company. Some of the research he/she did, looking at the impact of restoration on water quality and the value for the water company has led to our decisions [to focus on carbon for now. He/she keeps us up to date.]"*
> [P8, Peatland Code manager]

Based on a trusted relationship and regular exchange between P7, the Director of the IUCN UK Peatland Programme and P5, a nearby working policy officer, these two actors look for collaboration opportunities in order to enhance work on peatlands through the Peatland Code and peatland policy implementation via the Scottish government:

> *"How the Scottish government can work with us and what we can do to support them. […]"*
> [P7, Director of the IUCN UK Peatland Programme]

3) Categorised decisions: strategic, administrative and research decisions

Some decisions were often only categorised without further details of the decision and its content. The following quotes presented here, reveal some further additional information about the content of the decisions, if provided. As some network actors share the same working tasks, they also made various administrative decisions related to their work programme and day-to-day planning. Strategic decisions were made on what stakeholder groups to include from including various different sectors spanning from business to landowners. Within the research related decisions, knowledge is included for the decision-making process about methodological testing and interpretation of research results.

Strategic decisions:

Strategic decisions were for made example in relation to promotion and implementation of peatland restoration in a specific state in Germany – Mecklenburg-Pomerania. In this case, individuals were asked for advice on next priorities to make tactical decisions:

> *"Strategic issues with regard to promoting, implementing peatland restoration in Mecklenburg-Vorpommern."*
>
> [M11, scientist, regarding decisions based on communication with M12, the general MoorFutures manager]

> *"Decisions are mainly tactical. So, I am asking his/her for advice for priorities for the work program. What he/she thinks what we shall do next in our work program? What tasks we should be doing […]".*
>
> [P7, the Director of the IUCN UK Peatland Programme, regarding decisions based on communication with P14, the chair]

Strategic decisions were also often made in relation to inclusion of expertise on how to reach out and communicate to different stakeholder groups. Some decisions related to communication with all stakeholders while others related to specific groups, such as the business sector, policy sector and landowners. This included decisions on how to promote the peatland product (for example the Peatland Code) to the business sector, how the policy sector can support the Peatland Code product and how to create win-win situations with landowners, as well as transferring knowledge about the importance of protecting ecosystem services so they can implement peatland protection on the ground. The following quotes highlight this:

> *"More strategic issues about peatland management and how to communicate to different stakeholders."*
>
> *[M11, a scientist, regarding decisions based on communication with M2]*

> *"It is pretty tactical discussion around how we engage the business sector and how to promote the code to them."*
>
> [P7, the director of the IUCN UK Peatland Programme, regarding decisions based on communication with P6]

> *"With his/her it is high level policy – just agreeing – tactics to promote and support the code. Agreeing on tactical support."*
>
> [P7 regarding decisions based on communication with P13]

> *"He/she has lots of experiences with peatland restoration on the ground. Works with lots of landowners – lots of knowledge how to best enter into agreements with them about delivering ecosystem services and how to convince them that it is a worthwhile endeavour. […]*
>
> [P8, the Peatland Code manager, regarding decisions based on communication with P2]

Administrative decisions:

Participants also made administrative decisions in situations where they work together at the same workplace and need to share their workload, including planning daily tasks and their common work program. For example:

> *"[…] But also administration decision, because we both work in the same working group at the university. […] how we share tasks and so on."*
> [M11, scientist, about decisions related communication with M1, scientist and political negotiator]

> *"Day to day planning. Work programming."*
> [P7, the director of the IUCN UK Peatland Programme, on decisions with P8, the PC manager]

Research decisions:

Various research decisions were made in the context of testing research results and how these can be interpreted (M11). A further more specifying example is provided where P8 exchanged and discussed knowledge about actual carbon numbers to include into the Peatland Code. Whereas P8 specifically asked P20, a peatland practioner, for his/her practical knowledge, which he/she fed into new survey methodology which was then used for the development of the Peatland Code:

> *"Scientific decisions. […] how we test results and what they actually tell us."*
> [M11, scientist about decisions based on communication with M5, scientist]

> *"[P18] is the scientific … We discuss carbon numbers within the code. Seeking his/her advice on how we develop the carbon numbers."*
> [P8, the PC manager regarding decisions with P18, scientist]

> *"He/she is a restoration prof. [P20] gives really good knowledge on restoration in the fields and project he/she has been working on. [P20] influenced some of my decisions on creating a survey methodology for the PC and how to go about […]. Really practical information …"*
> [P8, about decisions based on knowledge exchange with P20, practioner]

4) Group decision-making versus dyadic decision-making

The quantitative parts of the interviews solely focussed on dyadic relationships between two actors. However, additional qualitative data reveal the role of group decision-making in contrast to decisions being made based on the communication with just one actor. Here participants describe subtle notions of a relational, co-operational, co-producing approach of decision-making that takes a group or trusted team. For example:

> *"I do not decide anything about MoorFutures alone."*

[M8, scientist]

"I'd say, no direct decisions, but we are together in this decision finding process. That is some kind of process."

[M7, scientist]

"It is more like, slowly minor shifts, that happen, that you would not say – yes, because I talked with him, that I made my decision or that I changed my view of how these things work. Within this closed network, at least for me, for where I am, this communication is very often and we are on a similar level and we often have the same idea at the same time." […] "We mutually made decisions based on our communication."

[M5, scientist]

Finally some participants were not able to separate individual decisions they made based on the communication with the other actors. In the following example this was due to the intensity of the knowledge exchange M12 had with M11 [scientist]:

"Of course I decide based on this communication. However, I cannot say which ones. Cause, that is such an intensive exchange, that I mention any specific decision. They are numerous decisions."

[M12, MF coordinator]

In conclusion, after exploring and highlighting the range of decisions that were made based on the communication that case study actors had with each other, the next section presents the results from exploring these communication and decision-making network structure.

4.3 Results: Exploration and visualisation of knowledge exchange and decision-making network structures

In order to explore how the structures of social networks influence the success of knowledge exchange and evidence-informed decision-making the overall structures of the networks were compared. This highlighted clusters of actors (indicating homophily versus heterophily), centrality versus periphery located actors and amount of in- and outdegree and betweenness of each actor (see direction of the arrows). Analysing the number of potential connections in each case study network revealed that there are 182 possible connections in the MF network and 380 in the PC network. Looking across the 20 actors in the Peatland Code network and 14 in the MoorFutures network, it soon become apparent that not everyone knows/knew each other. Network 1 – which looks into who knows who - shows that there are 130 relational statements that actors know each other in the MF network (71% of all possible connections) and 212 in the PC network (56%). The knowledge transfer network (network 2) has 84 connections (46% of all possible connection) in the MF and 143 (38%) in the PC network. The knowledge reception network (network 3) has 83 (46%) connections in the MF and 132 in the PC network. For network 4 83 (46%) dialogue connections were stated in the MF and 106 connections (28%) in the PC network. Finally in network 5, actors from MF case study stated they made a total of 73 (40%) decisions and PC actors stated that they made 101 (27%) decisions. For all five networks the MF networks have a higher density compared to the PC network.

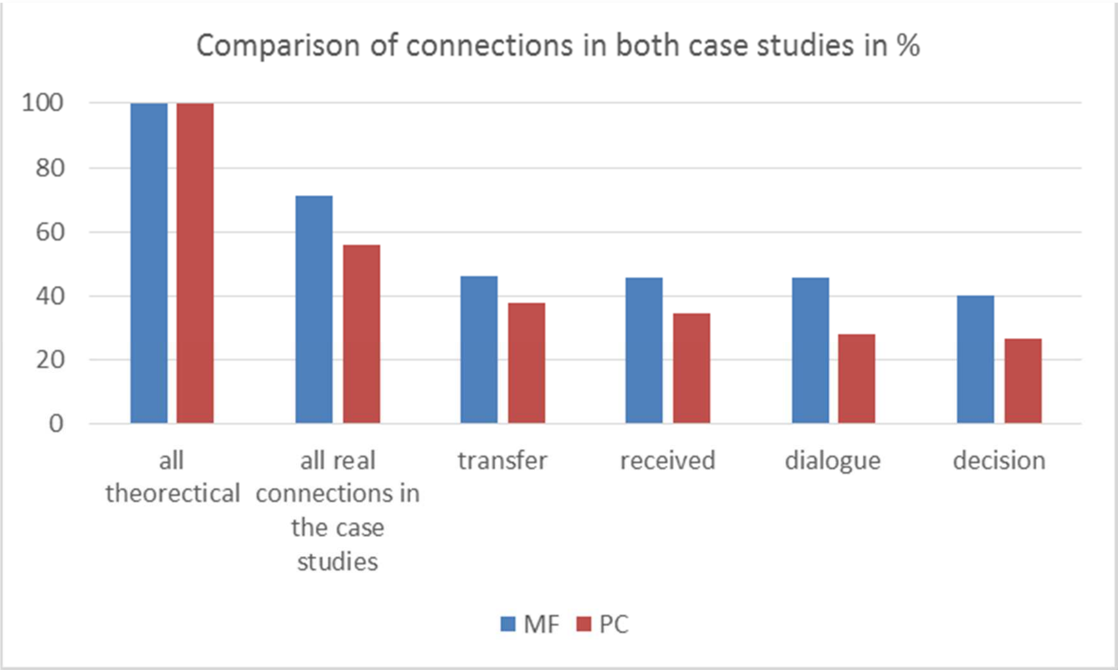


Figure 4. 2 Comparing both case studies regarding their overall possible network connections (100% baseline) with the in reality existing connections as described by the interview participants, the analysed knowledge transfer and reception relations, the dialogue and decision connections.

4.3.1 The MoorFutures network

The MoorFutures case study network consists of 14 identified actors (see Table 4.1 below). All were interviewed with the exception of M13 [politician] and M14 [coordinator of MoorFutures in Brandenburg]. M14 turned down an interview and M13, a politician, could not be accessed directly for an interview as a colleague acted as a gatekeeper.

MF actors	Profession/Role in the network
M1	*Scientist/Political negotiator*
M2	*Scientist/policy officer*
M3	*Project coordination of MoorFutures in Schleswig-Holstein*
M4	*Scientist*
M5	*Scientist*
M6	*Policy officer for MoorFutures in Brandenburg*
M7	*Scientist*
M8	*Scientist*
M9	*Communications spokesperson*
M10	*Marketing and PR for MoorFutures in Schleswig-Holstein*
M11	*Scientist*
M12	*General MF coordinator, owner of MF trademark*
M13	*Politician*
M14	*Coordinator of MoorFutures in Brandenburg*

Table 4. 1 List of all actors and their profession/role in the MoorFutures network.

network	who knows who			transfer network			received network			dialogue network			decision network		
actor	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness
M1	12	11	5.842	10	6	2.71	8	9	6.382	10	9	12.421	8	7	9.293
M2	12	9	1.142	8	7	3.893	7	9	7.589	8	6	8.393	7	7	10.471
M3	11	10	3.392	6	7	9.105	5	8	8.593	8	6	13.207	7	3	10.762
M4	10	8	0.1	5	4	1.143	3	7	1.971	4	2	0.575	2	3	3.65
M5	12	9	1.142	8	6	2.236	8	7	1.421	7	6	1.727	9	5	5.483
M6	6	5	0.1	2	0	0	0	2	0	2	0	0	6	0	0
M7	12	10	3.842	7	5	0.143	7	7	1.444	7	6	1.961	5	6	0.893
M8	12	10	2.675	10	7	5.486	8	8	4.087	8	7	4.192	4	5	1.083
M9	11	10	3.517	7	8	13.271	8	8	15.583	8	9	15.969	6	5	17.076
M10	4	6	0	3	2	0	2	3	0	3	2	0	3	2	0
M11	11	11	5.242	9	9	9.902	9	7	4.91	9	10	11.838	8	9	13.352
M12	13	12	12.008	9	10	20.112	9	8	16.021	6	10	14.717	8	9	12.936
M13	3	8	0	0	6	0	3	0	0	3	4	0	0	5	0
M14	0	11	0	0	7	0	6	0	0	0	6	0	0	7	0

Table 4. 2 Social network analysis scores (outdegree, indegree, betweenness) for all actors in the MoorFutures case study (see details for all actors in Table 4.1 above) for all five networks (network 1: who knows who in the network?, network 2: who transfers knowledge to whom in the network?, network 3: who perceived to have received knowledge from whom?; network 4: who is in a dialogue about knowledge with whom? and network 5: who makes decisions based on the communication with whom?)

The first analysed network looks into the question who knows who in the MoorFutures network (Figure 4.2). It was found that M12 [general MF coordinator], who is the coordinator of the MoorFutures project, has the highest possible outdegree centrality score of 13 (additional explanation to degree centrality scores above), which means he/she knows all other people in the network (see Table 4.2 above for all detailed scores). All actors that were interviewed stated that they know M12 (indegree centrality score of 12). M6 [Policy officer for MoorFutures in Brandenburg] and M10 [Marketing and PR for MoorFutures in Schleswig-Holstein] are known by less than half of all other people in the network (indegree centrality scores of 5 and 6 respectively). These two actors also do not know all other actors (outdegree of 6 and 4 respectively). M13, a politician, is known by others (indegree centrality score of 8), but most people state that they do not know M13 personally. M12 has the highest betweenness score of 12.01, which means he/she is positioned "between" all other actors in the network. The other actors have betweenness centrality score between 0 and 5.84 with a mean of 2.79 and a standard deviation of 3.23.

M12 [general MF coordinator] and M7 [scientist] have the highest closeness centrality scores of 100.00, which means both can directly reach out to others in the network as they know them personally. M1, M8, M5 and M2 [scientists, political negotiator and policy officer] follow with closeness centrality scores of 92.86 each and are also more directly connected within the overall network. The other actors have a closeness centrality score between 7.14 and 86.67 with an average of 78.60 and a standard deviation of 24.04.

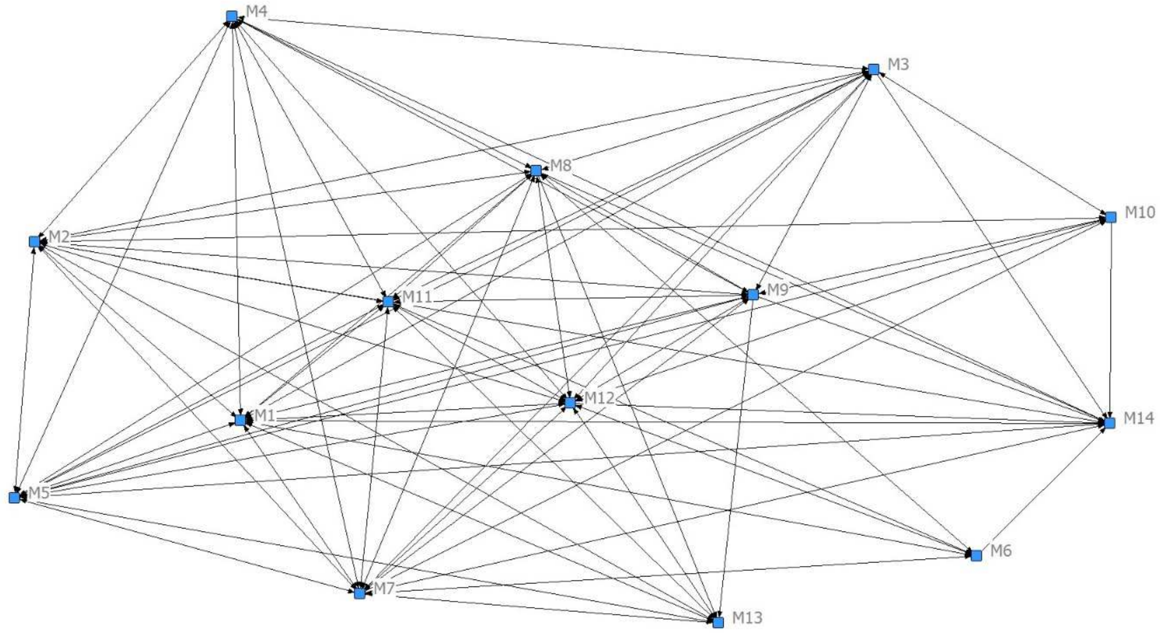


Figure 4. 3 Network 1 for the MoorFutures case study. Nodes represent each actor (see details for all actors in Table 4.1 above) and the edges show the relation who knows who in the network.

The second network analysis analysed the one-way knowledge transfer network amongst the 20 MoorFutures actors (Figure 4.2). Degree centrality scores for transfer of knowledge reveal that M1 [scientist and political negotiator] and M8 [scientist] transfer knowledge to 10 people (outdegree centrality score of 10), followed by M12 [general MF coordinator] and M11 [scientist] to 9 other actors in the network (both outdegree centrality score of 9) and M5 [scientist] and M9 [communications spokesperson] to 8 other actors (outdegree centrality score of 8). All other interviewed participants have outdegree centrality scores between 2 and 7. Ten actors in the network send knowledge to M12 (indegree centrality score of 10), nine to M11, and eight to M9 (indegree centrality scores of 9 and 8 respectively). M12 has the highest betweenness centrality score of 20.11 and best diffuses knowledge directly to other actors. M9 also connects the network via transfer of knowledge with a betweenness centrality score of 13.27. The other actors score between 0 and 9.90 with a mean of 4.86 and a standard deviation of 5.92.

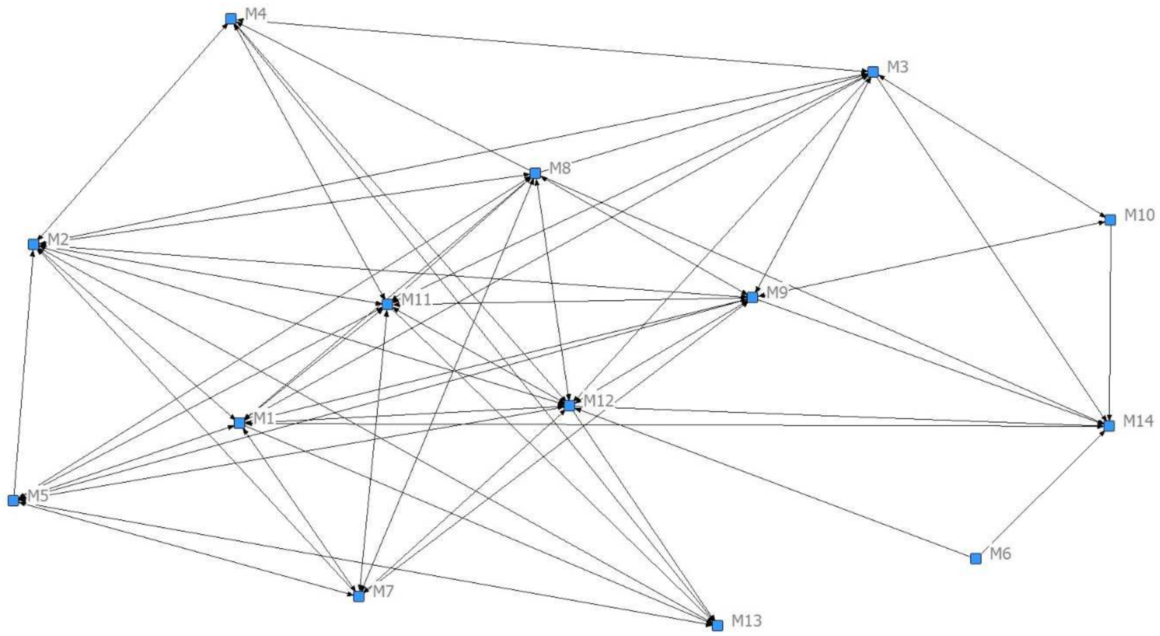


Figure 4. 4 Network 2 for the MoorFutures case study. Nodes represent each actor (see details for all actors in Table 4.1 above), the edges show who transferred knowledge to whom in the network and the arrows show the direction of the transfer.

The third network analysed the received perception of the one-way knowledge exchange (Figure 4.3). M12 [general MF coordinator] and M11 [scientist] received knowledge from 9 other people in the network (outdegree centrality scores of 9), followed by M1 [scientist and political negotiator], M5 [scientist], M8 [scientist] and M9 [communications spokesperson] all with an outdegree centrality score of 8. The eight other actors have outdegree scores between 0 and 7. M11 [scientist] and M2 [scientist and policy officer] perceived to have received knowledge from 9 people (indegree centrality score of 9). M12 [general MF coordinator], M8 [scientist], M3 [project coordinator of MoorFutures in Schleswig-Holstein] and M9 [communications spokesperson] received knowledge from 8 other network actors. The remaining interviewed actors perceived to have received knowledge with indegree centrality scores between 2 and 7. M12 has the highest betweenness centrality score of 16.02, followed by the M9 with a score of 15.58, which means they have the best access to knowledge directly from the other actors in the network. All other actors score between 0 and 8.59 in the betweenness centrality, with a mean of 4.86 and a standard deviation of 5.28.

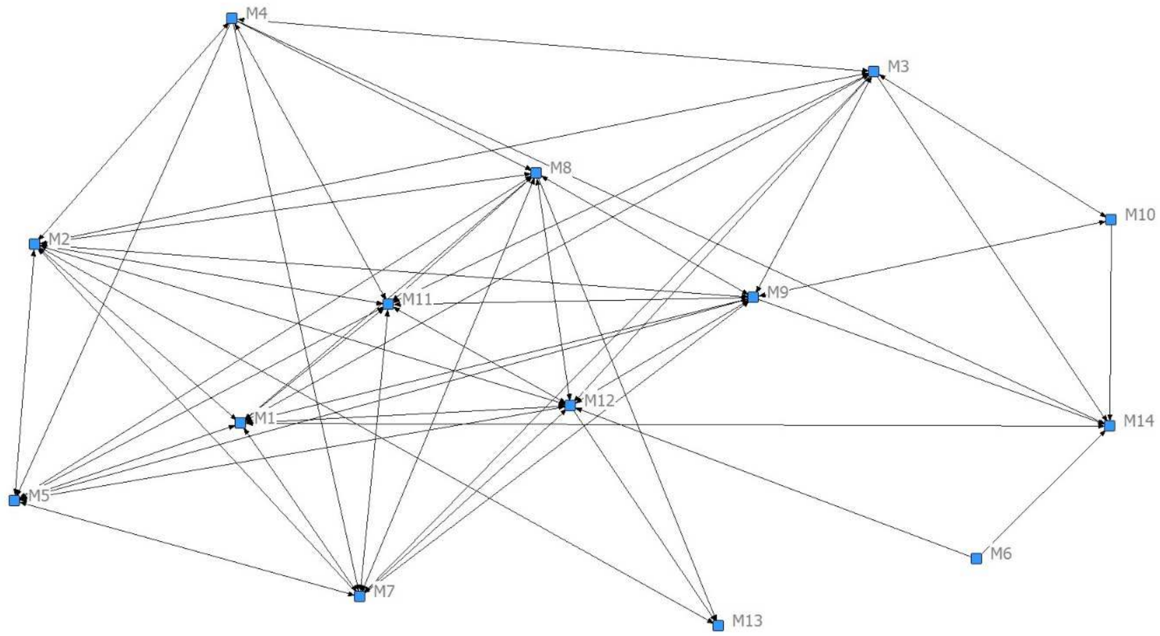


Figure 4. 5 Network 3 for the MoorFutures case study. Nodes represent each actor (see details for all actors in Table 4.1 above) and the edges show who received knowledge from whom in the network.

The fourth network analyses the network based on interviewees who stated they have been in a dialogue with the other actors in the network (Figure 4.4). M1 [scientist and political negotiator] has the highest outdegree centrality measure for dialogue, as he/she stated that he/she is in dialogue with 10 other network actors, followed by M11 [scientist] (outdegree centrality score of 9). From all interviewees, M6 [policy officer for MoorFutures in Brandenburg] mentions the least dialogue partners (outdegree centrality score of 2). All other interview partners' outdegree centrality scores are between 3 and 8. M11 [scientist] and M12 [general MF coordinator] have the highest indegree centrality, which means ten people stated that they are in dialogue with them, followed by M1 [scientist and political negotiator] and M9 [communications spokesperson] (indegree centrality score of 9). M9 has the highest betweenness centrality score of 15.97, followed by M12 [general MF coordinator] with 14.71, M3 [project coordinator of MoorFutures in Schleswig-Holstein] with 13.21, M1 [scientist and political negotiator] with 12.41 and M11 [scientist] with 11.84. All remaining network actors have betweenness centrality scores between 0 and 8.39 with a mean of 6.07 and a standard deviation of 6.09.

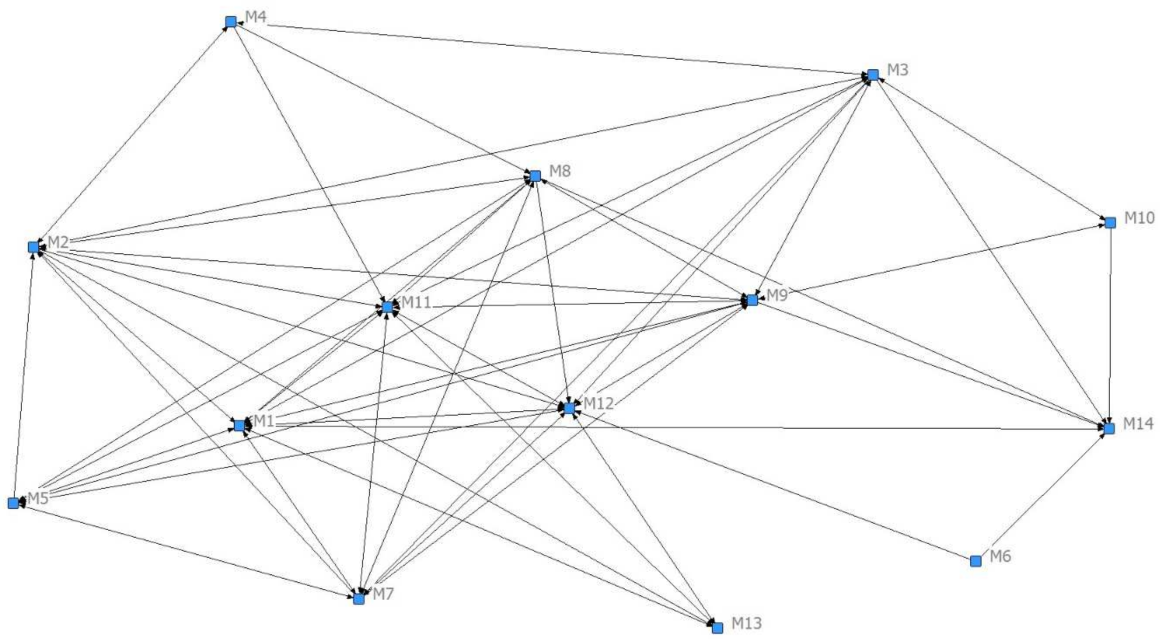


Figure 4. 6 Network 4 for the MoorFutures case study. Nodes represent each actor (see details for all actors in Table 4.1 above) and the edges show who of the actors stated an exchange of knowledge via dialogue with whom in the network.

The fifth network analysis presents the decisions that interview attendees made based on the communication they had with other network actors (Figure 4.5). M5 [scientist] stated that he/she made decisions with 9 out of all other network actors (outdegree centrality score of 9). M12 [general MF coordinator], M11 [scientist] and M1 [scientist and political negotiator] made decisions with 8 other people (outdegree centrality score of 8). All other interviewees made decisions based on the communication with 2 to 7 other network actors. Nine network actors stated they made decisions based on the communication with M11 and M12 (indegree centrality score of 9). All other actors score in indegree centrality between 0 and 7. The only person who's in and outdegree match is M2 [scientist and policy officer], who stated he/she made decisions with 7 people and 7 people stated they made decisions based on the communication with him/her. However, these 7 people are not the same in both directions. None of the other actors in and out degree score match 100%, which means that no mutual decision-making takes place, where one actor makes decisions based on the communication with the other and vice versa. M9 [communications spokesperson] has the highest betweenness centrality score with 17.08, followed by M11 (13.35) and M12 (12.94), which means these three are positioned on the shortest communication (receiving, transferring of knowledge and dialogue about knowledge) path between two other actors in the MoorFutures network. M6 [Policy officer for MoorFutures in Brandenburg], M10 [Marketing and PR for MoorFutures in Schleswig-Holstein], M13 [politician] and M14 [coordinator of MoorFutures in Brandenburg] all have a betweenness score of 0. With this they are positioned on the periphery of the network (see Figure 4.5 below). The remaining seven actors have betweenness centrality score between 0.89 and 10.76 with a mean for the entire network of 6.07 and a standard deviation of 5.85.

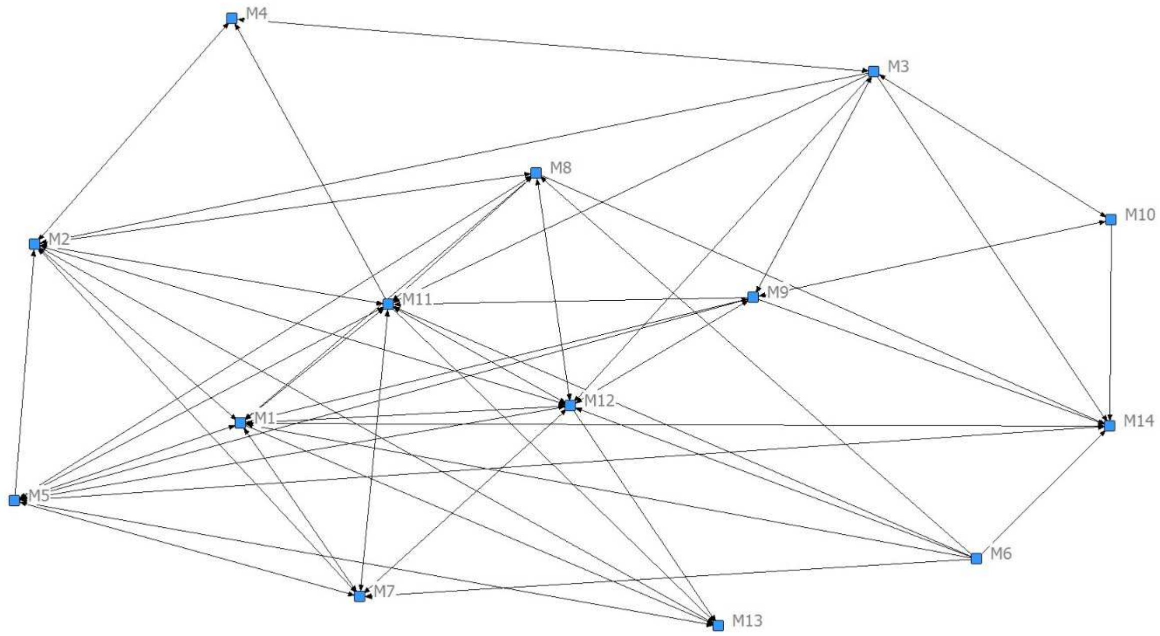


Figure 4. 7 Network 5 for the MoorFutures case study. Nodes represent each actor (see details for all actors in Table 4.1 above) and the edges show who made decisions based on the communication with whom in the network. The arrow represent the direction of this decisive relationship.

4.3.2 The Peatland Code network

The Peatland Code case study network consists of 20 identified actors (see Table 4.3 below). All were interviewed with the exception of P19 and P20. P19 did not respond to interview requests and P20 could not schedule an interview within the available data collection timeframe.

PC actors	Profession/Role in the network
P1	*Researcher*
P2	*Practioner*
P3	*Intermediary/Broker*
P4	*Advisor on carbon standards, techniques and infrastructure*
P5	*Policy officer*
P6	*Brings in broader environmental management expertise and connection to other network*
P7	*Director of the IUCN UK Peatland Programme*
P8	*Peatland Code manager*
P9	*Member of Peatland Code Executive Board, brings in expertise on conservation and access*
P10	*Represents interests from across the water utilities sector, advising on tactical issues*
P11	*Practioner*
P12	*Brings in land managing background and expertise*
P13	*Advises on climate and farming interests*
P14	*Chair person*
P15	*Policy officer*
P16	*Connects to the Scottish business and local government community*
P17	*Policy officer*
P18	*Scientist*
P19	*Brings in conservation expertise*
P20	*Practioner*

Table 4. 3 List of all actors and their profession/role in the Peatland Code network.

network	who knows who			transfer network			received network			dialogue network			decision network		
actor	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness	outdegree	indegree	betweenness
P1	18	16	21.775	10	13	15.833	15	7	14.588	6	11	7.567	6	8	4.158
P2	13	11	4.528	6	7	2.867	8	6	4.926	6	4	5.683	9	6	7.833
P3	13	10	3.077	8	6	1.583	5	8	6.79	8	6	7.793	11	5	5.125
P4	17	12	12.246	12	7	9.1	8	11	22.193	5	7	4.367	5	8	5.958
P5	11	11	6.656	2	6	0.167	7	6	6.162	4	4	3.5	4	3	1.583
P6	5	6	0	3	6	0.167	2	5	0.4	3	3	0	2	3	0
P7	19	17	27.492	18	15	65	15	16	75.774	17	14	122.931	19	14	121.658
P8	19	16	22.658	19	14	58.683	13	14	45.369	11	10	31.586	14	8	21.742
P9	9	9	2.006	6	6	1.167	5	7	17.869	5	3	10.46	5	4	1.042
P10	10	12	3.219	9	4	0.367	4	7	1.929	7	1	5.667	6	4	0.958
P11	12	9	2.526	7	7	3.817	7	9	10.879	6	7	13.06	5	4	2.658
P12	5	7	0.143	4	4	0.25	4	5	2.133	4	3	0.667	3	3	0
P13	7	8	0.222	4	4	0	3	5	0	6	2	1.033	0	3	0
P14	11	10	1.616	0	7	0	1	7	0.5	0	2	0	0	4	0
P15	6	6	0	1	5	0.25	2	1	0	1	2	0	0	2	0
P16	4	7	0.125	16	3	2.383	2	3	0	3	2	0.25	3	1	0
P17	14	12	6.536	7	7	21.65	7	8	23.705	7	7	24.569	4	3	1.583
P18	19	14	15.175	11	9	9.717	12	7	10.783	7	9	10.869	5	10	9.7
P19	0	8	0	0	4	0	4	0	0	0	2	0	0	3	0
P20	0	11	0	0	9	0	8	0	0	0	7	0	0	5	0

Table 4. 4 Social network analysis scores (outdegree, indegree, betweenness) for all actors in the Peatland Code case study (see details for all actors in Table 4.3 above) for all five networks (network 1: who knows who in the network?, network 2: who transfers knowledge to whom in the network?, network 3: who perceived to have received knowledge from whom?; network 4: who is in a dialogue about knowledge with whom? and network 5: who makes decisions based on the communication with whom?)

The first analysed network looks into the question who knows who in the Peatland Code network and reveals the following results (for visualisation of the network see Figure 4.6 below). P7 [director of the IUCN UK Peatland Programme], P8 [Peatland Code manager] and P18 [scientist] know all other network actors (outdegree centrality score of 19, see Table 4.2 above for all detailed scores), whereas all remaining actors do not know all other network actors (outdegree centrality scores between 4 and 18). P7 is known by 17 other actors (indegree centrality score of 17), P8 [Peatland Code manager] and P1 [researcher] by 16 other people (indegree centrality score of 16) whilst the other actors are known by less people (indegree centrality scores between 6 and 14). There are no 100% matches of people knowing each other, which mean, that if one stated he/she knows someone, it does not mean the other stated the same in reverse. P7 has the highest betweenness centrality score of 27.49 and is therefore known directly by almost all people in the network. P8 has a betweenness centrality score of 22.66 and P1 [researcher] 21.78. The other actors score between 0 and 15.18 in the betweenness centrality. The mean betweenness centrality is 6.50 and the standard deviation 8.42.

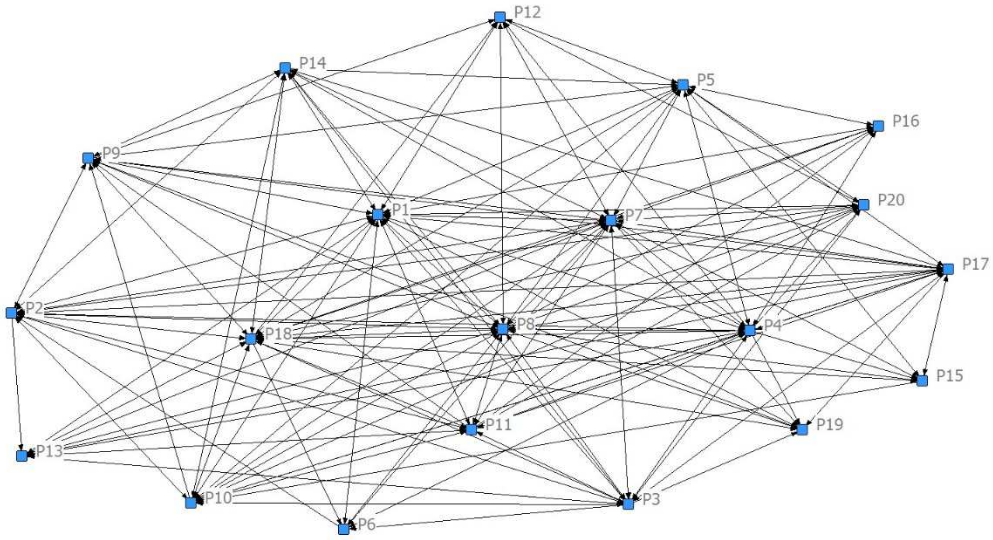


Figure 4. 8 Network 1 for the Peatland Code case study. Nodes represent each actor (see details for all actors in Table 4.3 above) and the edges show the relation who knows who in the network.

The second network analysis analysed the one-way knowledge transfer network amongst the 20 Peatland Code actors (Figure 4.7). P8 [Peatland Code manager] transferred to all 19 other network members, P7 [director of the IUCN UK Peatland Programme] to 18 and P16 [connects to the Scottish business and local government community] to 16. In reverse 15 people transferred knowledge to P7 and 14 to P8. If one person stated he/she transferred to another person, this does not mean that the same person transferred knowledge back and vice versa. P7 has the highest betweenness centrality score (65.00) followed by P8 with (58.68) and are therefore the best knowledge diffusers in the network and provide knowledge to the other actors directly. P13 [advises on climate and farming interests] P14 [chairperson], P19 [brings in conservation expertise] and P20 [practioner] all score 0 in betweenness centrality, where the last two were not interviewed. All other actors scored between 0.17 and 21.65. The mean betweenness centrality score is 9.65 and the standard deviation 18.35.

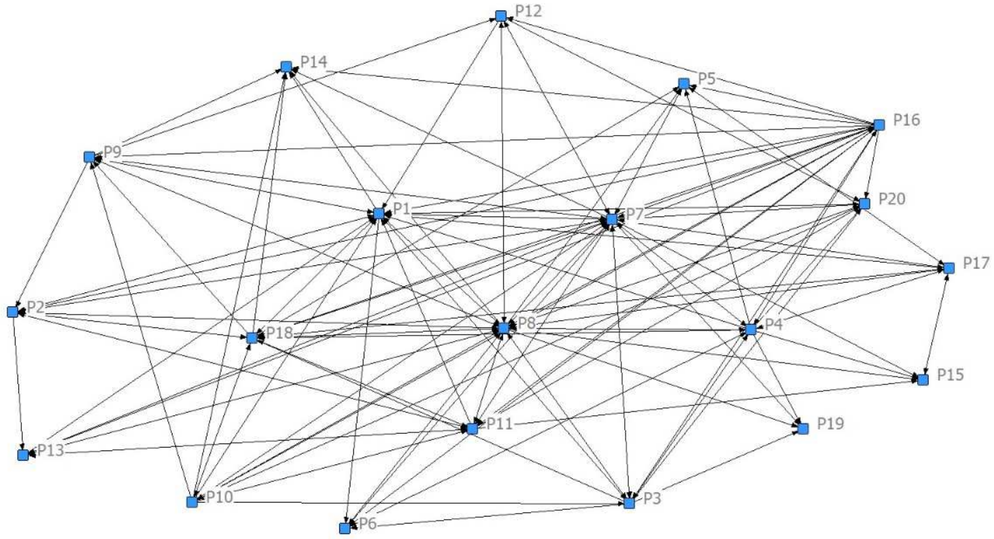


Figure 4. 9 Network 2 for the Peatland Code case study. Nodes represent each actor (see details for all actors in Table 4.3 above) and the edges show transferred knowledge to whom in the network. Arrows represent the direction of the knowledge transfer.

The third network analysed if participants perceived to have received knowledge via a one-way exchange (Figure 4.8). P7 [director of the IUCN UK Peatland Programme] and P1 [researcher] received knowledge from 15 other people in the network (outdegree centrality scores of 15), followed by P8 [Peatland Code manager] with an outdegree centrality score of 13 and 12 for P18 [scientist]. All other actors score in between 1 and 8. P7 perceived to have received knowledge from 16 people (indegree centrality score of 16). P8 received knowledge from 14 other network actors. The other actors perceived to have received knowledge from 1 to 11 other people (indegree centrality score between 1 and 11). P7 has a betweenness centrality score of 75.77, which means he/she has the best access to knowledge directly from the other actors in the network. P8 scores 45.37 in betweenness centrality, P17 [policy officer] with 23.71 and P4 [advisor] with a score of 22.19. All other actors score between 0 and 17.87 in the betweenness centrality, with a mean of 12.20 and a standard deviation of 18.39.

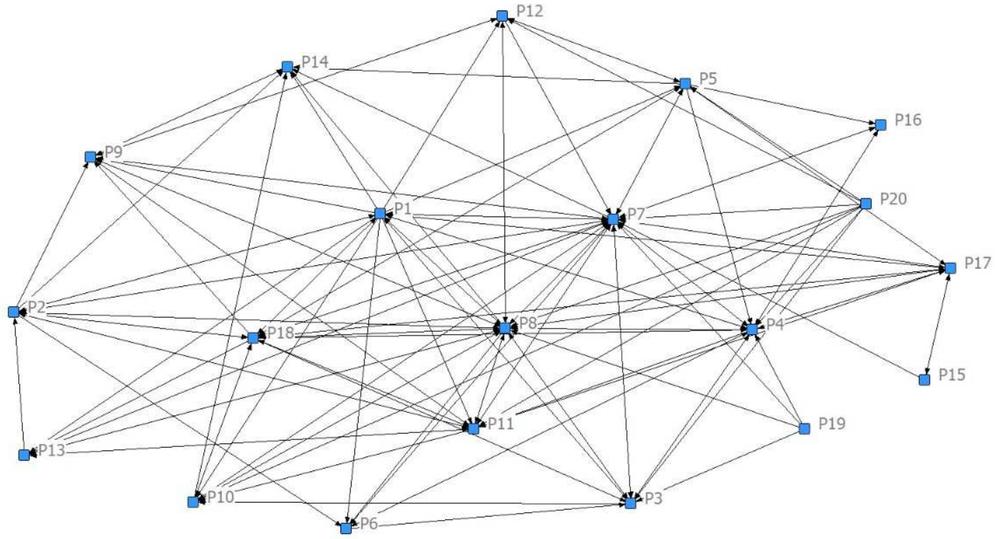


Figure 4. 10 Network 3 for the Peatland Code case study. Nodes represent each actor (see details for all actors in Table 4.3 above) and the edges show who received knowledge from whom in the network.

The fourth network analyses the network based on interviewees stating they have been in a dialogue with others in the network (Figure 4.9). P7 [director of the IUCN UK Peatland Programme] stated that he/she is in dialogue with 17 other actors (outdegree centrality score of 17) and P8 [Peatland Code manager] with 11 (outdegree centrality score of 11). The other interviewed actors have outdegree centrality scores between 0 and 8. 14 networks actors state they are in dialogue with P7 (indegree centrality score of 14), 11 actors with P1 [researcher], 10 with P8 and 9 with P18 [scientist] (indegree centrality scores of 11, 10 and 9 respectively). Perception between network actors who stated they were in a dialogue with another person matches in no cases in reverse direction.

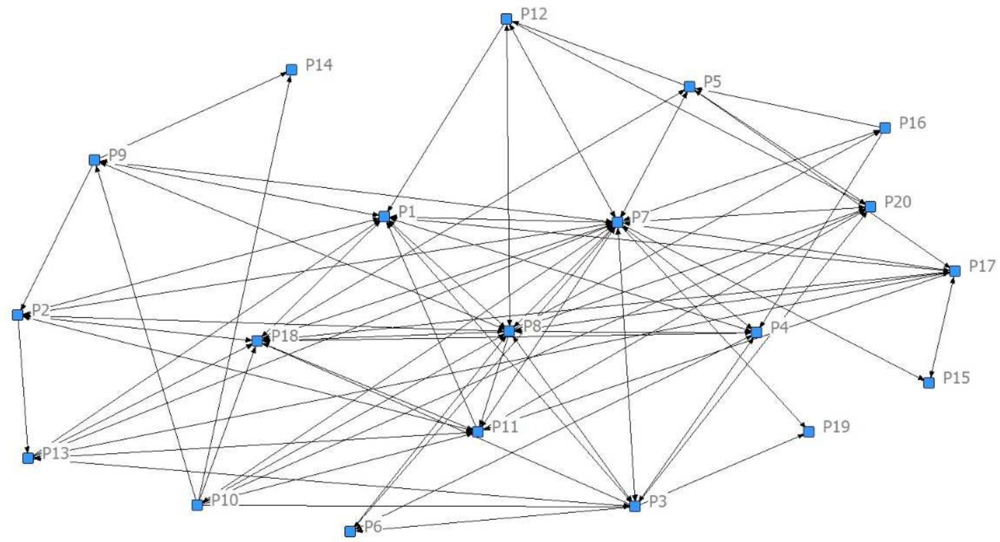


Figure 4. 11 Network 4 for the Peatland Code case study. Nodes represent each actor (see details for all actors in Table 4.3 above) and the edges show who exchanged knowledge via dialogue with whom in the network.

The fifth network analysis presents the decisions that interviewees made based on the communication they had with other network actors (Figure 4.10). P7 [director of the IUCN UK Peatland Programme] made decisions based on the communication with all other network actors (outdegree centrality score of 19). He/she is followed by actor P8 [Peatland Code manager] with an outdegree centrality score of 14. All other actors score in outdegree centrality between 0 and 11. In reverse, 14 actors made decisions based on the communication with P7 (indegree centrality score of 14). All other actors score in indegree centrality between 1 and 10. P7 has the highest betweenness centrality score of 121.66 and made the most decisions directly based on the communication with the other network actors. All others have betweenness centrality scores between 0 and 21.74, with a mean of 9.20 and a standard deviation of 26.30.

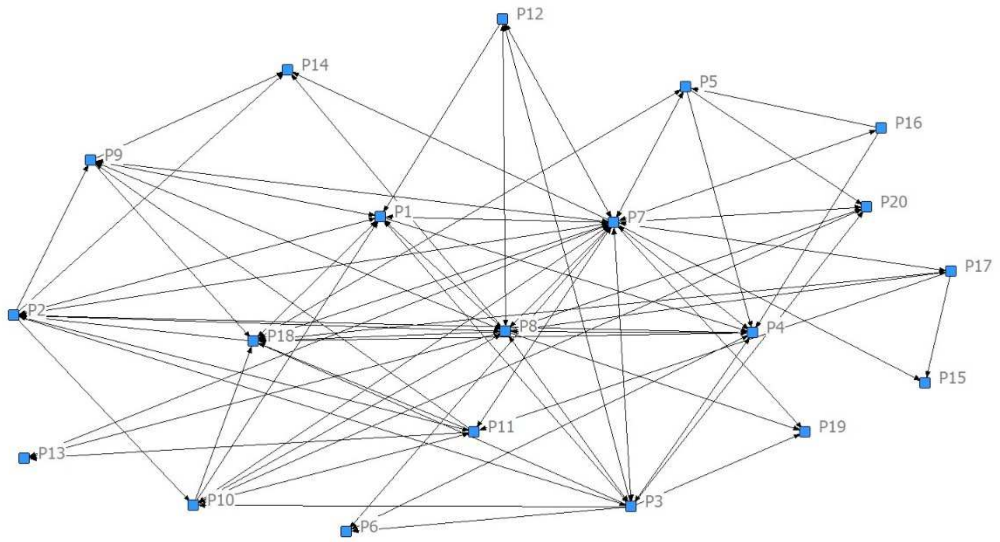


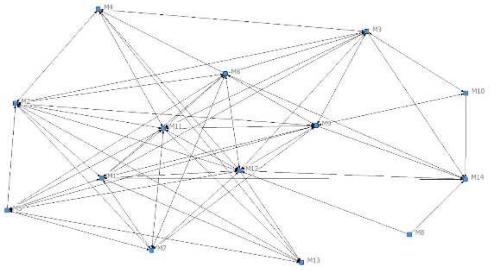
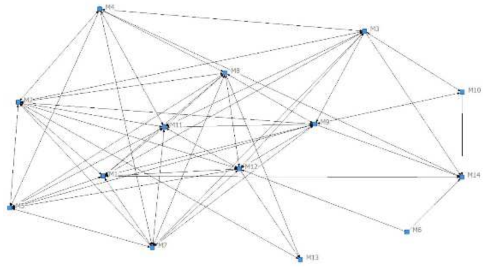
Figure 4. 12 Network 5 for the Peatland Code case study. Nodes represent each actor (see details for all actors in Table 4.3 above) and the edges show who made decisions based on the communication with whom in the network. The arrow represent the direction of this decisive relationship.

4.4 Discussion

4.4.1 Impact of knowledge flow and knowledge exchange on decision-making

There is broad consensus in the academic literature about the benefits of two-way versus one way dialogue, with the wide-spread applied linear model of knowledge exchange subject to longstanding critique (van Kerkhoff and Lebel, 2006; Koetz et al., 2011; Pielke, 2007; Ward et al., 2012; Watson, 2005). Referred to as knowledge deficit model by Cvitanovic et al., (2015) and supply push model by Knight and Lyall (2013), this model assumes that scientists provide research evidence to policy makers (mainly by scientific publications) and that they then come to well informed decisions. However, some global assessments, such as the Global Biodiversity Assessment (Heywood and Watson, 1995), have failed to be taken up by policy makers because they did not engage these relevant stakeholders in a two-way dialogue before and during or after completion (Watson, 2005). Though the Global Biodiversity Assessment was a high standard academic document, it lacked governmental ownership and mandate (Watson, 2005) and its linear communication model meant it had almost no impact on policy formulation (Watson, 2005; Young et al., 2014). It has therefore been recommended that a two-way dialogue amongst networks of researchers, practitioners and policy makers might be more suited (Koetz et al., 2011; Young et al., 2014) to find solutions and make decisions to safeguard the environment.

However, the above critique falls short of some explanations, as it focusses on the one-way transfer of knowledge alone. Even though the data from my research confirms the mismatch between transfer of knowledge and decisions being made, the explanation seems to lie also in the lack of perception to have received knowledge (further supporting results from the Bayesian network analysis can be found in chapter 5). Figure 4.12 below allows for overall comparison and demonstration of the overall similarities of the combined visualised network structures. Detailed network connection characteristics can be found in the network Figures 4.1 - 4.11 above. Even though the transfer and reception networks for each PC and MF case study seem similar at first, looking at the details differences become apparent: there are 84 knowledge transfer (Figure 4.12a) and 83 knowledge reception connections in the MF case study networks (Figure 4.12b). In the PC study there are 143 transfer connection, however only 132 reception connection (Figures 4.12c and d respectively). This means that looking at the specific directions of these connections (see network Figures 4.1 - 4.11 above for the details), it becomes clear that, if one actor stated that he/she transferred knowledge to another actor in the network (network 2) the other actor does not always stated that he/she actually received the knowledge (network 3) (see Figure 4.12 comparing these networks). This mismatch in turn can disable evidenced informed decision-making. Tailored communication addressing the target person's knowledge needs is required (see chapter 6 and Laurance et al., 2012; Lövbrand, 2011; Tinch et al., 2018).

a)  b) 

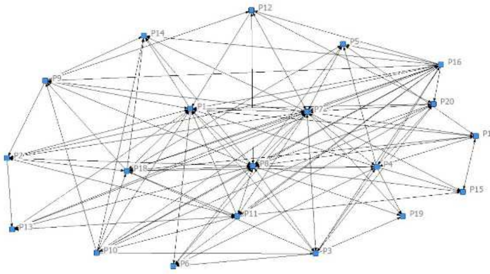
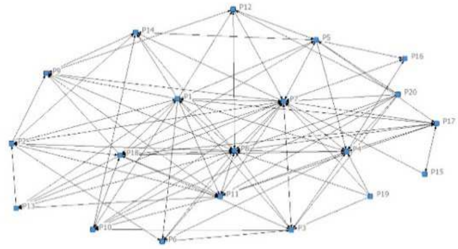
c)  d) 

Figure 4. 13 Combined Figures 4.3 and 4.8 representing transfer network 2 (a) and c)) and Figures 4.4 and 4.9 representing the reception network 3 (b) and d)) of the MoorFutures (a) and b)) and Peatland Code (c) and d)) case study. They allow for overall comparison and demonstration of the similarities of the combined visualised network structures. Detailed network connection characteristics can be found in the network Figures 4.1 - 4.11 above.

This is why many authors ask for the two-way dialogue (Koetz et al., 2011; Young et al., 2014). This is when the transfer and reception networks would fully match. In a dialogue stakeholders' chances improve to clarify if their transferred knowledge is indeed received by the other person. Analysed dialogue and decision networks (networks 4 and 5) in both case studies show some overlap (see combined Figures 4.13 below). Combined Figures 4.13 allow for comparison and demonstration of the similarities of the combined visualised network structures (detailed network connection characteristics can be found in the network Figures 4.1 - 4.11 above). The decision networks (Figures 4.13b and d) still contain less connections compared to the dialogue networks (Figures 4.13a and c) (83 dialogue versus 73 decision connections in the MF study and 106 and 101 connections in the PC study respectively). Not every dialogue led to decisions, but a high correlation can be found between dialogue and decision-making. Perhaps not all of the knowledge received via these dialogue interactions, led to decisions immediately. Decision making can also occur with time delay.

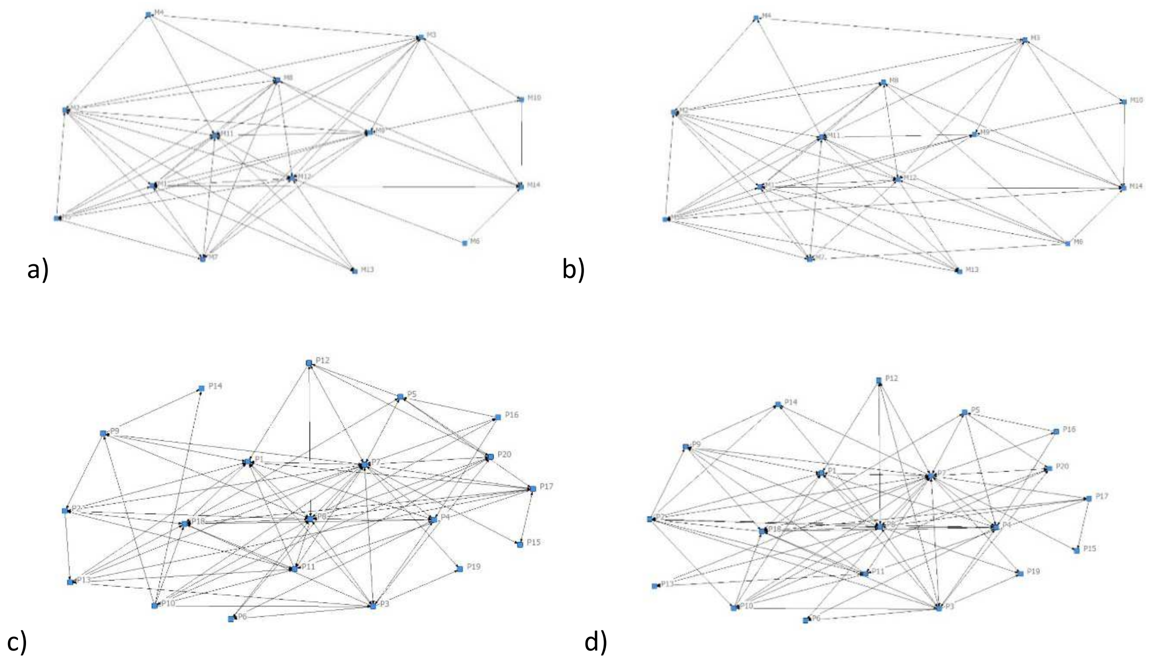


Figure 4. 14 Combined figures 4.5 and 4.10 representing dialogue network 4 (a) and c)) and figures 4.6 and 4.11 representing the decision network 5 (b) and d)) of the MoorFutures (a) and b)) and Peatland Code (c) and d)) case study. They allow for comparison and demonstration of the similarities of the combined visualised network structures. Detailed network connection characteristics can be found in the network Figures 4.1 - 4.11 above.

The comparison of the percentage of actual knowledge exchange and decision connections with number of potential connections in each case study network reveals there are proportionally less connections in the PC case study compared to the MF study (see Figures 4.2, 4.7 and 4.13 above). This might be explained by the currently less centralised nature of the PC study, as the MF study has a longer project running time (see further discussion on centralisation below in section 4.4.2). In conclusion looking at one-way communication in more detail reveals important elements including the importance of successful reception of knowledge as part of successful evidence-informed decision-making.

4.4.2 The impact of network and network actor characteristics on knowledge exchange, knowledge uptake and decision-making processes

The relational structures and positions of actors within networks play crucial roles in the circulation of knowledge (see above and for example Dowd et al., 2014; Cunningham et al., 2015; Cvitanovic et al., 2017). According to Fischer and Jasny (2017) social capital theory refers to network actors being positioned in the network to build trust and a mutual understanding of relevant problems. They exchange knowledge and resources and collectively address these problems at stake. Individual node attributes, such as in and outdegree centrality and betweenness centrality, are able to shed light into the location of individuals and their roles within the communication networks.

To evaluate the impact of network structures and network actor characteristics, various questions can be addressed: Who is central and why and what are the attributes of centrally positioned network actors? First what does centrality mean? Centrality is an attribute describing how central each person is in the network (Freeman, 1979). High scores can be interpreted as people who are more visible (Fuhse, 2018; Prell, 2012; Wasserman and Faust, 1994, see scores for each actor in Tables 4.2 and 4.4 above in sections 4.3.1 and 4.3.2 respectively). They know many other actors and are known by many other people in the network (see network 1; and Wasserman and Faust, 1994). Central actors can inhibit a broker role bridging between otherwise disconnected parts of the network (Prell, 2009). They therefore play an important role in bringing diverse, heterophilic people and hence new, innovative ideas into the network (Bodin et al., 2006; Brass, 1992; Prell, 2003). The results from the social network analysis shows that high scoring network actors speak with many people and diffuse knowledge to others in the network. They are therefore major channels of information (see network 2; and Prell, 2012; Wasserman and Faust, 1994), receive/hear about information (see network 3; and Prell, 2012), are engaged in active dialogue (network 4; and Prell et al., 2009), and make more decisions based on the communication with others in the network (network 5; Mizruchi and Potts, 1998).

Looking even closer into the direction of ties in each network reveals further important information into the group structure (e.g. Prell, 2012; Wasserman and Faust, 1994). Indegree centrality scores for example represent the number of ties received by an actor by another actor from the network (Prell, 2012). High scoring actors hear about important information from others (Prell, 2012). Research by Prell (2012) showed that they are involved in more dialogue and their communicated knowledge appears more relevant for the decision-making of others. In contrast, outdegree centrality represents the number of ties directed to an actor by other actors from the network (Prell, 2012). These people spread knowledge and information within the network and are important diffusers (Rogers, 2003). If people score high in both in and outdegree centrality, this means they perform knowledge broker roles and are essential for the knowledge flow and diffusion in a network (Prell, 2012; Rogers, 2003; Wasserman and Faust, 1994). In the Peatland Code network there is one particular actor who scores high in centrality across all 5 networks – P7 [director of the IUCN UK Peatland Programme], who has been involved in the project from the outset. P7 knows all other actors and has long-term relationships with most of them (some relationships already lasting over 20 years). P7 was key in initiating the network and is key in developing it. P8 [Peatland Code manager] scores second in all separate analysed Peatland Code networks. P8 manages the information and knowledge flow and even scores highest in outdegree centrality. These two actors are the main diffusers of project related knowledge. See Table 4.3 for all Peatland Code network actors and their profession/role in the network.

In comparison in the MoorFutures network there is actor M12 [general MF coordinator], called the “father of the MoorFutures” (by M7, scientist), who scores high in several analysed network attributes (see Table 4.1 for a list of all MoorFutures network actors and their profession/role in the network and Table 4.2 for all network scores above in section 4.3.1). However, M12 does not always score highest or with such a significant difference to a second scoring actor, like P7 in the Peatland Code case study. Working also in a policy role, the MoorFutures project does not cover 100% of M12’s daily working tasks. M9 [communications spokesperson] scores highest in betweenness centrality in the dialogue and decision networks in the MF case study (see MF networks 4 and 5) and second in betweenness centrality in the knowledge transfer and receiving networks (network 2 and 3). Betweenness centrality considers the position of actors in the network and calculates how many times each of them is positioned on the shortest connection path between two other actors in the network (Freeman, 1979; Prell, 2012). In that Prell (2012) continues and states that between centrality is the most powerful measure of centrality, as it takes into consideration the rest of the network and not only the direct neighbouring actor ties. Betweenness centrality means that someone is critical for the information flow of the network as he/she is able to connect different subsections of the network and acts as a broker, as an intermediary person. If these actors are removed the networks would fall apart. If the betweenness centrality score is low, that mean that so called weak ties might exist between these actors in these networks (more on “weak ties” below). In contrast, high scoring actors form strong(er) communication network ties in the network (they usually transfer and receive more knowledge and are involved in active dialogue about this knowledge). According to Prell (2012) betweenness centrality scores have a greater variance and the differences between actors become clearer compared to other centrality measures (Freeman, 1979; Wassermann and Faust, 1994). Bodin and Crona (2009) allocates these high scoring actors an important role in network, as they are able to diffuse or maybe do not diffuse relevant information. The authors continue to state that these actors can act as "bridging tie" and decide to influence the flow of resources (in the case of my study knowledge) between others and therefore hold a position of power in the network (Schiffer and Hauck, 2010), that they can use strategically. In connection to my results from the BN analysis in chapter 5 there is strong evidence that there is a link between dialogue and decision-making (likelihood to make decisions is higher, if people had a dialogue about knowledge). This was also true, if people perceived the actual reception of knowledge from another actor in the network (the reception networks can be found in Figures 4.4. and 4.9 and the scores for betweenness centrality for these particular networks in Tables 4.2. and 4.4. respectively). See section 5.3 for further discussion of the findings from the Bayesian network analysis.

Centralisation and adaptive network development over time

Crona and Bodin (2006) and Olsson et al. (2004) discuss the value of centralised networks in the initial project phase, where the network is formed (Prell et al., 2009). Comparing the dialogue and decision networks for the Peatland Code and MoorFutures case studies (see Figures 4.12 and 4.13 for a visual broad comparison in section 4.4.1 above) a difference in the betweenness centrality score distribution becomes apparent (see Tables 4.2 and 4.4 for all actor scores above). Whereas the Peatland Code network relies on actor P7 [director of the IUCN UK Peatland Programme], who scores highest with a significant difference to the second scoring actor in the dialogue and decision networks (network 4 and 5). Betweenness centrality scores in the MoorFutures network are not spread as far apart and the network structure has a more coherent stability. The stability of the network might be jeopardised over time if there is only one central actor who scores very high including some significant differences to the second scoring actor. Such a network only relies on this one person to hold the network together and may struggle, if this person would need to leave the project. Centralised networks can in fact be a disadvantage to plan and find solutions for these issues long-term (Crona and Bodin, 2006; Prell et al., 2008). Mascia and Mills (2018) found that decentralised decision-making network structures enable better adoption to issues at stake. Achieving long-term success requires decentralised structures, where more than one actor and actor group hold both weak and strong ties (Crona and Bodin, 2006; Reed et al., 2009).

Coming back to the data from the case studies it is clear that the MF study is less centralised compared to the PC case study. MF has a longer project running time. Both case studies include actors who joined the network at later stages – around 2 years prior to the interview being conducted. M9 [communications spokesperson] and P8 [project manager] both inherit legitimised roles in each of the networks. Even though both joint at a later stage they play an important part in the development of sustainable decentralising network structures. The MF's projects' initial phase has passed and some success has already been achieved, regarding the selling of

MoorFutures certificate for restoring peatland ecosystems. Whereas the PC had only two registered peatland restoration projects[37] at the time of the interviews in 2018.

Network actor roles during phases of the project

To support the network structure development, the chairs'/directors'/project managers' initial task is to select relevant network actors. This actor selection can be done deliberatively (Sandström et al., 2013) and via stakeholder analysis (Prell et al., 2009; Reed et al., 2009; Reed et al., 2018) and ideally include valuable contexts and resources from pre-existing networks (Sandström et al., 2013). In the case of the MoorFutures case study no stakeholder analysis has been systematically and regularly been conducted and a key stakeholder might have been left out because of this. The missing evolvement of this key stakeholder caused and still does various difficulties and jeopardised/s the implementation and success of the MoorFutures product. The Peatland Code board selection in turn was informed by a stakeholder analysis (Dougill et al., 2006), but no formal re-evaluation of the stakeholder analysis has been done since. P11 [practioner] for example was deliberately chosen for the PC network, as he was research manager at a peatland NGO at the time. Due to his official role he was known by many UK peatland stakeholders from research, practice as well as policy and including him in the initial network development phase was crucial for the development of the Peatland Code network. This initial phase is followed by glueing together the network (Crona and Bodin, 2006; Olsson et al., 2004) towards a common goal (Cvitanovic et al., 2018) and initiation of trust building (Lee and Harris, 2013). The following quote from a workshop participant highlights that he/she thinks that it is important that all relevant people are involved in a network and there is the opportunity that everyone honestly speaks their opinion. He/she believes trust a very important for this:

> *"I think that trust is very important. […] As long as you have got objectively all the people around the table putting their points of view […] as long as everyone is honest around the table that is the important thing. You have to trust what the other person is actually saying is true."*
>
> [Participant from the stakeholder workshop]

A knowledge broker who acts as a facilitator and network manager (Klijn, 2005) from the outside and throughout the project can be helpful (Knight and Lyall, 2013; Reed et al., 2018) to ensure

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[37] See current status of registration on http://www.iucn-uk-peatlandprogramme.org/peatland-code-registry accessed on 18 March 2019.

that both the network contains homophilic as well as heterophilic connections (see more in this topic below) for successful knowledge exchange leading to decisions being made.

Once the project is up and running central positioned legitimised actors are also responsible for organising regular meetings (see chapter 5 for more details on the impact of the frequency of communication on the probability of decision-making). Regular meetings play a role in enabling a more stable network, as people actually get to know each other and communicate regularly. This increases probability that actors make decisions based on the communication they have with fellow stakeholders (see chapter 5 for details). A further value of meeting (e.g. in conferences) is stated by the following person who took part in the stakeholder discussion:

> *"I am thinking about the Peatland Code in terms of networking so I think that one of the key things that comes out of the IUCN conference is that networking amongst the groups, making sure we learn lessons from other people."*
>
> [Participant from the stakeholder workshop]

The more people know each other and communicate, the more decentral the networks becomes (Prell, 2009). One could expect that all people who score high in the first network and know most people, are the ones who know each other the longest. This might be true for the person with the highest score in network 1 – P7 [director of the IUCN UK Peatland Programme] and M12 [general MF coordinator]. Both are the initiators of the project. But actors P8 [Peatland Code manager] and M9 [communications spokesperson] also score high in this network analysis, however both only got involved in the project around 2 years prior to the interviews being conducted (as discussed above). Both, P8 and M9 are responsible for managing the main part of the communication in their network and allocate a huge proportion of their time into these tasks: a full-time position in the case of P8. The involvement of these two further contributes to decentralise the network structure.

Structural holes

Structural holes (Burt, 1992) are empty spaces in social structures, actors who do not have connections - edges - between them. A valuable function of actors with high betweenness centrality scores such as M9 [communications spokesperson] is that they cover those so called structural holes. For successful knowledge exchange in science-policy networks, and hence evidenced-informed decision-making, it is necessary to close "structural holes", knowledge gaps between individuals and other (sub-)networks with complementary resources or information (Burt, 1992). This could be achieved by bridging organisations (Berkes, 2009; Fischer and Jasny,

2017) or individuals acting as knowledge brokers (Bielak et al., 2008; CHSRF, 2003; Lavis et al., 2003; Meyer, 2010; Russel et al., 2010, Ward et al., 2009a, Ward et al., 2009b). There are actors in both networks who close structural holes, thus bringing diversity and new ideas to the network (Bodin et al., 2006; Brass, 1992; Prell, 2003; Prell et al., 2009). Such knowledge brokers can bring in and diffuse knowledge to other networks (e.g. Granovetter, 1973, Rogers, 2003). M9 [communications spokesperson] and M3 [Project coordination of MoorFutures in Schleswig-Holstein] are such actors, they are the only two actors to link M10 [Marketing and PR for MoorFutures in Schleswig-Holstein] to the network, who would otherwise be separated.

The periphery and importance of weak ties

Each network also has more peripherally located actors (see all actors' scores in Tables 4.2 and 4.4 in sections 4.3.1 and 4.3.2 above respectively). Lower scores in in and outdegree and betweenness centrality indicate their periphery positions (e.g. Wasserman and Faust, 1994). However, what are the reasons for actors to be positioned in this part of the network and what roles do these actors play? All actors located at the periphery only allocate a small percentage of their working time towards each case study project. Some are involved on a regular basis, some more irregular or not at the current stage of the project, but have been in the past or will possibly be involved more in the future (see also chapter 5 for more details on the frequency of communication). It is important to keep in mind that all analysed networks present a glimpse in time of each of the projects. Interviewees were asked to think back to the year prior to being interviewed when stating their answers and are also depending on the actors' perspective at the very given moment of the interview (Gerring, 2004). A further explanation of a periphery position is highlighted by actor P13 [advisor], who was unclear about why he/she were invited in the network in the first place and might have therefore chosen to stay less engaged in the network.

Periphery network positions only become apparent if closed networks are studied, which mean they have defined boundaries. In fact every person is part of multiple networks (e.g. Mucha et al., 2010) and inherit both more central or periphery positions in each of them. These network boundaries for both chose case studies were selected including the people mentioned on the Peatland Code website and with the MoorFutures coordinator. PC clearly and transparently state their (board) members, whereas MF does not. In the case of the MF case study this lead to XP1 not being included in the interviewee selection however, XP1 was mentioned multiple times by various interviewees, who see the person as really important for the project's success.

Furthermore, there are also network actors who have a higher indegree than outdegree score. These actors hear about important information from others (Prell, 2012) and are important listeners. This is for example a valuable characteristic of a neutral chairperson, who facilitates meetings and by listening to all he/she can create trust (e.g. Tinch et al., 2016).

> *"I would say that you have a chair, who creates a space and it is a safe space now, because the trust then blooms in that space."*
>
> [Stakeholder participants' reflection on the chairs role]

Given P14 [chairperson] lower outdegree scores he/she does not inherit central positions in the transfer, dialogue and decision network. However, given his role as chair person, it is difficult to explain why network 1, that looks into who knows who, reveals that P14 stated he/she knows only 11 people and is known by 10 people in the network, about half of all actors in the network. One would expect the chair to know all people and be known by all people. However, is seems like he is only part of a subgroup, consisting of people from the steering group of the Peatland Code. The periphery position of the chair is also a mismatch with expectations that were expressed by people present at the stakeholder workshop where initial results from the Peatland Code network were discussed:

> *"So you are saying the person at the bottom edge [P14 is positioned in the periphery to the top left side in the above presented network visualisation] is the chair?"* [puzzled]
>
> [Participant from the stakeholder workshop]
>
> *"I don't understand. I would expect the chair to communicate with lots more people."*
>
> [Participant from the stakeholder workshop]

P14's [chairperson] lower score in the receiving network can be explained with the fact the interviewees were asked to focus their answers specifically on knowledge exchange of peatland ecosystem services, however the majority of the knowledge exchange that P14 is involved is around other topics, including strategy. The MoorFutures network has no specific chairperson, who facilitates interactions during meetings.

Specialists' expertise and skills that are only needed on an infrequent basis, present a further reason for people being located in periphery positions:

> *"There is a challenge in the Peatland Code where you have individual specialists whose role is very specific and very technical and you can only expect one or two lines from that individual."*
>
> [Participant from the stakeholder workshop]

Wasserman and Faust, 1994 state that actors with low degree scores or not active in relational processes and a removal of these actors has no effect on the existing connections within the network, however one strength of an “outsider” is that they can be an essential connection to other networks, as everyone is part of several networks (Mucha, 2010). While connecting different networks, these actors are also able to close structural holes to these other networks or subnetworks and ensure that knowledge and information flows are maintained. It also means that further experts outside the network can be consulted, if their special skills and expertise are required for the success of the project.

Homophilic versus heterophilic network connection

Both of the case study networks consist of a combination of homophilic and heterophilic actors. The network analysis suggests that P1 [researcher], P4 [advisor], P7 [director of the IUCN UK Peatland Programme], P8 [Peatland Code manager], P11 [practioner] and P18 [scientist] are very homophilic in their knowledge base. As they regular communicate, they update each other on various aspects of peatland ecosystem service related knowledge and further relevant strategic information. Peripherally located network actors are important for both inclusion of their additional heterophilic knowledge from other networks as well as the spread knowledge to them and through them to further networks (see also section 5.3.6. on strong bonds to people outside the network). In the MoorFutures networkM1 [scientist and political negotiator], M5 [scientist], M7 [scientist] and M11 [scientist] form a subgroup. This is also due to the later being scientists from the same institute – close physical proximity - communicating and exchanging knowledge regularly including in person communication. They have worked together for a long time and formed similar opinions and gathered similar knowledge. However, they precisely know about their individual heterophilic strengths in order to optimally synthesise their combined knowledge. These homophilic versus heterophilic aspects are therefore influenced by the different scales covered by the two initiatives: PC being nationwide and MF being regional spread over 3 states in the North of Germany.

> [On deciding together] “We are all of us, I would say, but particular the closer network of M11 [scientist], M1 [scientist and political negotiator], M7 [scientist], and [additional person 1] and also count M12 [general MF coordinator] in that and [additional person 2], we are sort of on the same level and when we are communicating it is not that we are changing each other’s view.”
>
> [M5; scientist]

How knowledge spreads in social networks has been discussed in the literature, including the classic Diffusion of Innovation by Rogers (2003), where he specifically looks at models of communication transfer like the Two-Step-Flow-Model. With this research I extend on this and looked specifically on both one-way knowledge elements (transfer and reception) as well as studying the impact of two-way exchange of knowledge. According to Rogers' model, in decision making, people seem to be more influenced by direct and personal contacts than by mass media. Rogers' (2003) Two-Step-Flow-Model suggests that, both homophily where interacting individuals are similar in their characteristics, as well as heterophily where communicating individuals are very different (Crona and Bodin, 2009; McPherson et al., 2001), are considered important for the diffusion of new ideas, knowledge and arguments (Bodin and Crona, 2009; Fischer and Jasny, 2017; Tinch et al., 2018). Various literature mentions the importance of heterophily in shaping collective action, develop innovative ideas and sustainable solutions (e.g. Agrawal and Gibson, 2001; Poteete et al., 2010; Rogers, 2003). Coming back to homophily which helps to build trust in the other and the information and build strong ties amongst actors (e.g. Coleman, 1990; Friedkin, 1998; Henry and Dietz, 2011; Prell et al., 2009). These homophilic actors are passing messages and knowledge on to their fellow network actors and they are more likely to regard received information as valid for their own decisions (Henry and Dietz, 2011). To conclude: both homophily (based on working in the same institute in close proximity and the formation of homophilic knowledge bases due to regular knowledge exchange) and heterophily (based on additional knowledge on peatland ecosystem services transferred from and to the outside and the periphery of the networks) play a role in the composition of successful networks. Reality suggests it being a mixed-composition that is important for success and achievement of impact of the project. Homophilic subgroups ended up making more group decisions as well as a well facilitated connection of additional heterophilic periphery actors. In any case a conscious selection of the network actors according to their skills, expertise, social capital and pre-existing network links and not limited to their profession and location is advised (Sandström et al., 2013).

Role of weak ties

Amongst the terms used in social network analysis literature is "weak ties". There are some overlaps to structural holes and heterogeneity as described above. Weak ties tend to exist between dissimilar others (Granovetter, 1973; Prell et al., 2009). Various weak tie connections exist in both case study networks, for example as different sectors are included in the Peatland Code network, such as water sector, farming sector, business sector as well as research and policy.

So what is the role of weak ties? Actors connected via weak ties often communicate less than others or more infrequently (Granovetter, 1973; Prell et al., 2009). However, the real value of weak ties are that it is proven that they are a source of greater diversity of information and new ideas (Burt, 1992; Granovetter, 1973; Prell et al., 2009). This could be captured by additional qualitative material presented in section 4.2.2., which presents what kind of decisions were made between network actors. The quotes emphasise that some interviewees particularly valued and also trusted the knowledge, expertise and experiences these, mainly peripheral actors, added to their personal evidence base. Weak ties are able to make networks more resilient and adaptive in current environmental governance settings (Prell et al., 2009). A disadvantage of weak ties, is that they may break easy (Prell et al., 2009) compared to strong trusting connections communicating more frequently. Furthermore, multiple authors stated that, due to infrequent communication, some weak tie connections may lack trust and understanding required for worthy dialogue (Burt, 1992; Newman and Dale, 2004; Prell et al., 2009; Reed et al., 2009).

4.4.3 Evaluation of method

Social network analysis is a valuable technique (Best and Holmes, 2010; Prell et al., 2009; Reed et al., 2018) to study knowledge exchange amongst stakeholders. There are limitations to the method due to a small sample size (Reed et al., 2009), however the combination of quantitative and qualitative data analysis allows for an in-depth understanding of knowledge exchange and decision making relations among stakeholders involved (further results can be found in chapter 5).

Furthermore, social and geographical distance between actors is however a proxy measure of homo- and heterophily. In future research it would be useful to characterise similarities and differences in knowledge, values and beliefs of actors. To do this adequately would require an additional in-depth qualitative research component, which was not possible in the current research due to time limitations within the interview process (up to an hour per interview) and the range of data that needed to be collected in this time.

4.5 Conclusion

The social network analysis found evidence that knowledge exchange connections in science-policy interfaces matter for decision-making and consequently for the integration of ecosystem service knowledge in conservation policy. This chapter explored how the structures of social networks influence the success of knowledge exchange and evidence-informed decision-making. The chosen case study approach helped to identify network structures that promote effective knowledge exchange between science and policy actors in each of the selected case studies. A mismatch between knowledge transfer (networks 2) and knowledge reception (networks 3) has been found in both case studies and therefore highlights the need to focus on successful transmission of information to the target persons. The maximum success network structure would be achieved if the transfer network and knowledge reception network would fully overlap. Continuing from here if the dialogue and the decision networks fully match. In line with chapter 6 evidenced-informed decision-making can be improved by tailoring transferred messages to the target audiences' needs. In a dialogue, stakeholders can exchange knowledge two-ways and thereby further clarify if their transferred knowledge is indeed received by the target persons. This in turn led to more decisions being made based on the communication amongst stakeholders in the case study networks (overlaps between dialogue networks 4 and decision networks 5).

It has been elaborated that decentralised governance structures enable the reaching of better solutions to address environmental issues long-term. The collected data only allow to capture a snapshot in time of the studied networks. However, it is known that the MF project has started in one federal state in Germany and now involves three others (see more on the MF case study in section 3.2.2). Therefore, more people got involved over time. Whereas the PC project started with a clear distinguished executive board consisting of five people and a technical advisory board consisting of 15 people, from which 3 changed since the interviewees were conducted[38]. Naturally and if the project works well, more network actors get to know each other and form further connections, hence the network gets denser and less central. My research therefore suggest that with an adaptive management approach both case studies are in the transition between central towards more decentralised network structures, although the MoorFutures project is further ahead in this transition than the Peatland Code network (perhaps as it runs longer compared to the Peatland Code initiative). To allow for a stable decentralised, well connected network structure and exchange long-term, deliberate network management efforts seem helpful or even essential. This could include the support of professional knowledge brokers. Findings suggests that

[38] https://www.iucn-uk-peatlandprogramme.org/funding-finance/peatland-code/peatland-code-governance accessed on 16 June 2020.

at the beginning of network development, central actors can make deliberate stakeholder selection choices including weak and strong as well as homophilic and heterophilic network actors.

The social network analysis from this chapter recommends that a successful stable network consists of a combination of legitimised, credible and trusted individuals, who cover different roles and tasks. These include more centrally positioned actors responsible for facilitating, listening and creating the framework to create stable trusting relationships for effective knowledge exchange, actors who are responsible for bundling, transferring and diffusing knowledge within and beyond the network and actors located at the periphery whose expertise, views and ideas are included through regular meetings. Regular meetings (minimum once a year and individual exchange at least quarterly, see chapter 5) create opportunities for the entire network to ensure everyone knows each other and their skills and expertise and therefore creating essential network connections that enables stability over time. Results suggest that if each meeting is designed and facilitated to enable dialogue, the likelihood for successfully received knowledge increases, and therefore the likelihood for knowledge uptake and hence decision-making. The network development process takes time and ongoing maintenance. The chapter therefore concludes by calling for a deliberate network management. Hereby weak ties versus strong ties, together with the bridging of structural holes as well as homophily versus heterophilic actor composition should be actively and skilfully considered. Furthermore, decentralisation of networks can be strengthened by applying professional communication and mediative skills as well as meeting design expertise to allow for more network connections and these to be intensive and regular. This can be supported by “neutral” professional knowledge brokers and bridging organisations.

Chapter 5 - How to maximise the probability of evidence-informed decision making at the science-policy interface

5.1 Introduction

Environmental governance relies on sound, up-to-date evidence from science and practice, so it is of utmost importance to study the factors that enable this knowledge uptake to happen. Effective communication at the interface between biodiversity research, policy and practice is one essential ingredient to enable up to date research outcomes to be included in decision-making (Spierenburg, 2012; Young et al., 2013). To ensure that evidence is taken into account for environmental policy-making, science-policy communication and exchange of knowledge within functional relationships is vital (Bielak et al., 2008; Cvitanovic et al., 2015).

A range of factors that facilitate knowledge exchange are known and reflected in the work of Reed et al., (2014) who describe five principles of knowledge exchange: design, represent, engage, generate impact and reflect and sustain. It is known that stakeholders should communicate "often", "frequently", "regularly" or via "ongoing exchange" (Cvitanovic et al., 2018, Durham et al., 2014, Young et al., 2013), but how often exactly remains unclear, so does the relative importance of underlying knowledge exchange factors.

The aim of this chapter is to address the need to clarify the relative importance of different key factors enabling the best probability of knowledge uptake and evidence-informed decision-making to serve conservation. Hereby Bayesian network analysis methodology is tested on its suitability to address the above issue adequately. Specifically, the chapter asks: Should stakeholders communicate in person or via email or phone? At what point of the development of the relationship between scientists, policy makers and practitioners is knowledge taken up, trust formed, and finally decisions being made? What is the relative importance of these factors to increase the probability for decision-making in science-policy networks?

An in-depth analysis of the case studies which were introduced in Chapter 3, included structured interviews and an assessment of potential scenarios of knowledge exchange and decision-making using a Bayesian network analysis (Pourret et al., 2008). The results are enriched by additional qualitative data derived from the interview data that give in-depth insights to better understand results from the Bayesian network analysis.

Bayesian networks combine graph theory and probability theory (Stephenson, 2000). These graphs consist of nodes and edges. Each of the 11 nodes represent a variable. Edges represent conditional dependencies between variables. Under different scenarios the probability of the state of each variable is calculated by updating each of these conditional dependencies. A Bayesian network analysis was added to the method portfolio due to its strengths in computing probabilities; it therefore enhances the results from the structured interviews and gives insight into the parameters that seem important and relevant for decisions being made between two people in the studied social networks. Such in-depth analyses of knowledge uptake and decision-making of case studies have been rarely done, but they are able to provide empirically grounded guidance for effective science-policy processes (Reed et al., 2018).

The results of the Bayesian network scenarios presented in this chapter therefore provide precise evidence for the optimal frequencies and modes of communication to enable knowledge uptake and decision-making over time. Moreover, results of this research provide potential new empirical evidence into the question pertaining to when and how trust was formed and developed over the duration of the relationships of the two case studies and shed light into the factors necessary to build long-term trusting relationships that improve decision-making.

5.2 Results

The mixed-method approach (detailed description of the methodology can be found in chapter 3) shows the following results: thirty interviews revealed 573 individual communication connections between the case study actors within and beyond the two case studies. These led to 234 statements that one decision or more (41% of all possible network connections) were being made based on the communication people have had with each other. In 59% of all potential network connections, people did not make decisions based on communication about peatland ecosystem services of peatlands: The most obvious reasons for this is, that they did not know each other or did not talk to each other. What decisions were made based on knowledge exchanged is laid out in Chapter 4 section 4.2.2.

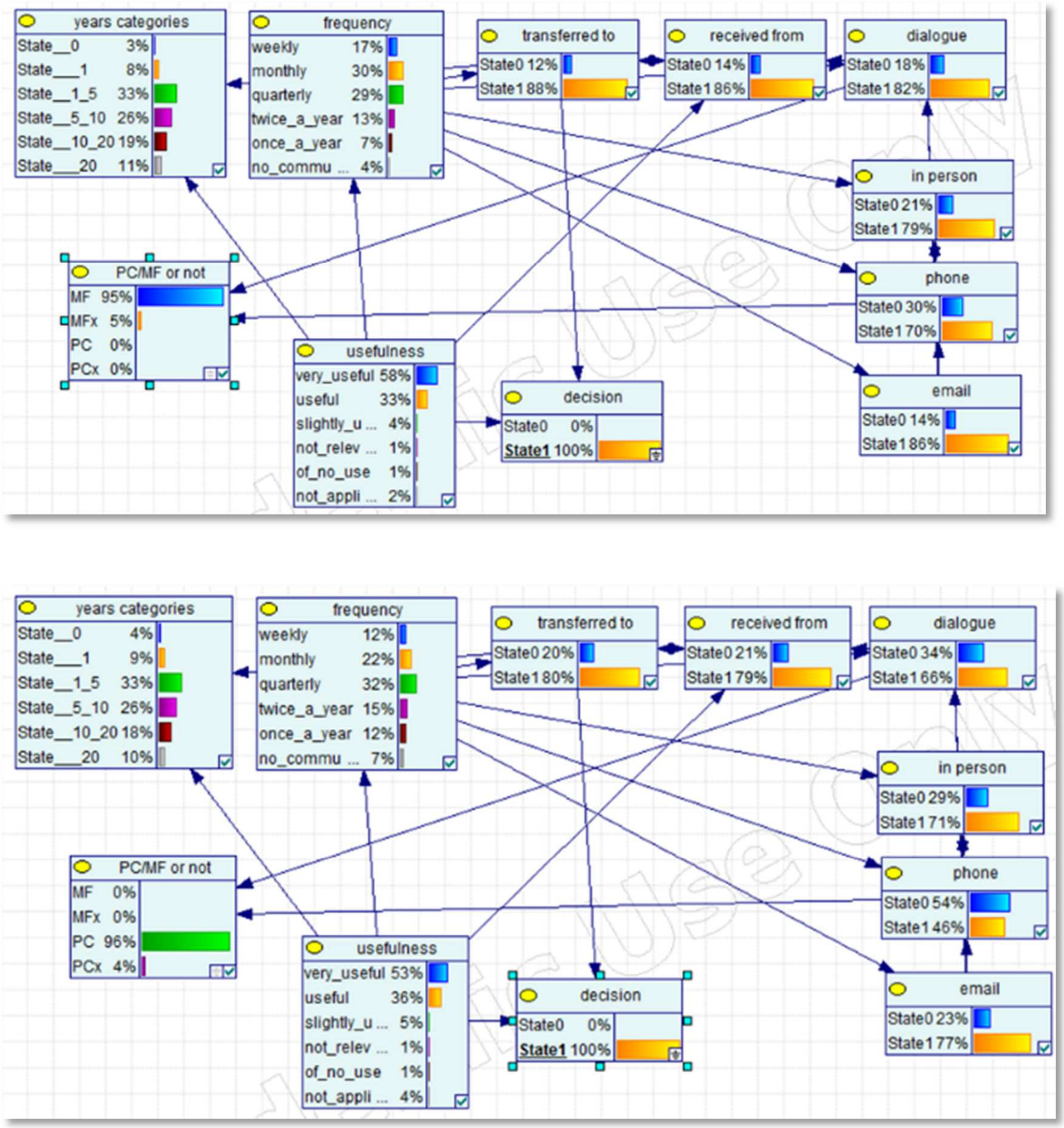
In order to find answers and test how to maximise the probability of evidence-informed decision making at the science-policy interface, seven scenarios were modelled. Results for these models are presented in the following sections. Further explanations on the methodology can be found in chapter 3 section 3.3.4.

5.2.1 Baseline scenario

In order to see how the probability to make decisions based in the communication between actors in each network can be maximised/improved it is important to compare all proceeding scenarios to the baseline scenario (the "*status quo*"). The baseline scenario represents the actual numbers derived from the Bayesian network analysis for each of the two case studies:
In the MoorFutures (MF) case study the probability that a decision is being made based on the communication the actors had with the others is 47% compared to 35% in the Peatland Code (PC) case study. Some actors do not know each other (25% in the MF and 35% in the PC study). While some people do not know each other, some people who do know each other do not communicate. The probability of people not communicating with each other is 34% for the MF and 49% for the PC study. Amongst all actors that do communicate – actors in the MF case study communicate more frequently, use all modes of communication with a higher probability and exchange knowledge both via one–way and also two-way direction. However the existing relationships are on average longer in the MF study than in the PC study. This data has been captured primarily as binary data. Sometime interviewees revealed further qualitative information, e.g. about the specific content of the communication. All communication connections (transfer, receiving and dialogue) always refers to knowledge exchange on ecosystem services of peatlands. The overall perception of the communication each actor had with the other was described with a higher probability with "very good" and "good" in the MF study versus the PC study. Further data are shown in Tables 1-3 in Appendix A-C.

5.2.2 Scenario 1 – 100% decision probability scenario – The optimal

The aim of the study is to find the optimal combination of factors to enable decision-making based on the communication between actors in closed case study networks. As a closed network, all identified actors within each network were invited to be interviewed to allow for the most comprehensive analysis of the entire networks as possible. The first scenario therefore deals with the optimal scenario, where the target - a 100% probability target - is set to the decision node in order to find out what the factors were that led to decisions being made based on the communication between the network actors (Figure 5.1). It should help to understand what would be necessary for all communication to lead to a decision, providing insights into the factors that are most important. However, this does not suggest that all communication should lead to decisions.



a)

b)

Figure 5. 1 a) Optimal scenario for the Bayesian network analysis for the MoorFutures case study; b) Optimal scenario for the Bayesian network analysis for the Peatland Code case study (analysed with the software GeNIe; Bayes Fusion LLC, 2017).

Figure 5.1 shows the optimal scenario for the Bayesian network of the MoorFutures (a) and Peatland Code (b) case study. Each node represents one of the 11 variables: "years categories" represent the length of the relationship, ranging from 0 to >20 years; "frequency of communication" represents six states ranging from no communication to weekly communication; "transferred to" represents the answer from each participants whether he/she transferred knowledge to each of the communication partners, with state 0 meaning no and state 1 meaning yes; “received from” represents the answer to whether or not people received knowledge from the other person, “dialogue”, whether or not they feel they have been in a dialogue with the other person; “in person”, whether or not they communicated with the other in person or via “phone” or “email”; “PC/MF or not” stated whether or not people are part of the PC or MF network or people mentioned beyond their network; “usefulness” represent answers to the questions on how useful the interviewees perceived the communication with the others to be: ranging from: not applicable, of no use, not relevant, slightly useful, useful to very useful; and the final node “decision” represents the answers to the question, whether or not people made a decision based on the communication with the other actors. The edges were computed by the Bayesian network model and represent only one option for a connection, not the complete picture of the interconnectedness of all nodes. Each node shows the probability of each of its possible states given the scenario 1 – a 100% probability for decision making for the MoorFutures study (Figure 5.1a) and for the Peatland Code case study (Figure 5.1b).

The results show that relationships between actors who made decisions based on their communication with each other are longer compared to the baseline scenario. Knowledge is transferred, received and exchanged via dialogue more frequently compared to the baseline scenario. The communication also happened with a higher probability in person, via phone and/or email in comparison to the baseline scenario. The PC actors use significantly less phone as a medium to communicate compared to the MF study.

5.2.3 Scenario 2a – The influence of the length of relationship on the probability of decision-making

To address the scenario whether the length of relationship influences decision-making, I start by introducing the distribution of how long people knew each other at the time of the interview and compared both case studies. There are 21.6% of people who do not know each other in the MF and 33.3% in the PC case study. This also influences the density of the network (see chapter 4). The majority of relations are between 1 and 5 years old: 25.9% in the MF case study and 32.3% in the PC study respectively. Overall MF connections are longer compared to PC connections. The MF case study runs longer than the PC study (see in the introduction to case studies in method chapter 3) and people worked together prior to the case study existence: 17.3% of actors in the MF study knew each other between 5 and 10 years, 7.3% in the PC study. 11.4% knew each other longer than 20 years in the MF case study and 2.3% in the PC case study.

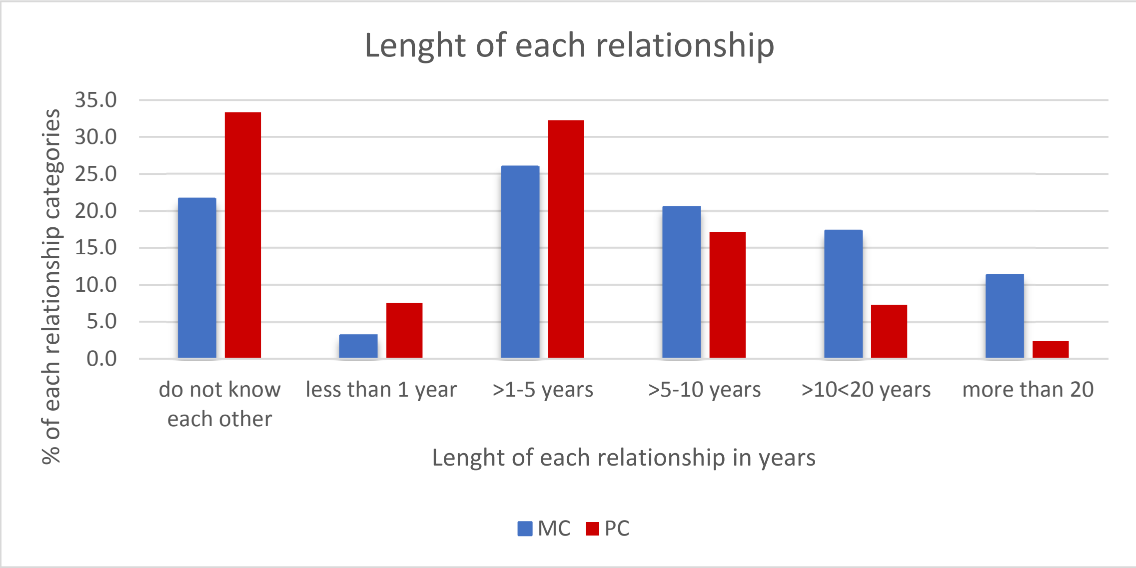


Figure 5. 2. Distribution of the each category of the length of the relationships for each case study.

In order to see if the length of the relationship influences the probability for evidence-informed decision-making, scenarios for each of the year categories were compared. For these analyses the target scenarios of 100% probability were set for each of the year categories separately. Results of the MF case study (see also Figure 5.3 and Appendix A for data Table 1) indicate that if people know each other up to 5 years the probability of making decisions is 53% and increases over time (5-10 years 65%, 10-20 years 71% and >20 years 73%). However, given that these results are based on only 15 pairs that have relationships >20 years, these results need to be interpreted with caution. The perceived usefulness, the frequency of communication and the transfer of knowledge, the reception of knowledge and dialogue about knowledge increases over time, as does the use of personal communication, communication via email and phone. Results of the PC case study show similar results, but with slightly lower probability in all numbers compared to MF study.

Furthermore, qualitative information was able to provide the description of a network contact existing years prior to the interviews being conducted. In the following example a participant described his/her motivation to build on previously built trust. This is in line with findings from Rust et al. (2020) and Saunders et al. (2010), resulting in a motivation to informally exchange and the openness to work together after several years. A good basis for the 65% probability for decision-making amongst relationships > 20 years in the Peatland Code case study.

> *"[Person] was in the year below me [at university]. We used to go caving together. […] Honestly it was more like a chat then a discussion about*

peatlands. […] But I was very pleased [the person] was on the Peatland Code steering group, as I had a chance to catch up with [the person] a bit better."

[P18, scientist]

5.2.4 Scenario 2b – Optimal scenario for each year category

These scenarios combine the previous two (scenario 1 and scenario 2a). Therefore, within the Bayesian network model scenario 2b 100% probability targets are set both on the length of relationship node and on the decision node, in order to find out what factors change and how it changes if 100% decisions are made over the duration of the relationships. The data analysis show that the optimal factors to enable decision-making in the case study networks change over time. Within each year category, scenario results reveal that when communication occurs more frequently, more knowledge is transferred, received and exchanged via dialogue, in person, via email and phone and the communication is perceived as more useful over the duration of the relationship for both case studies. Detailed data can be found in Table 1 in Appendix A.

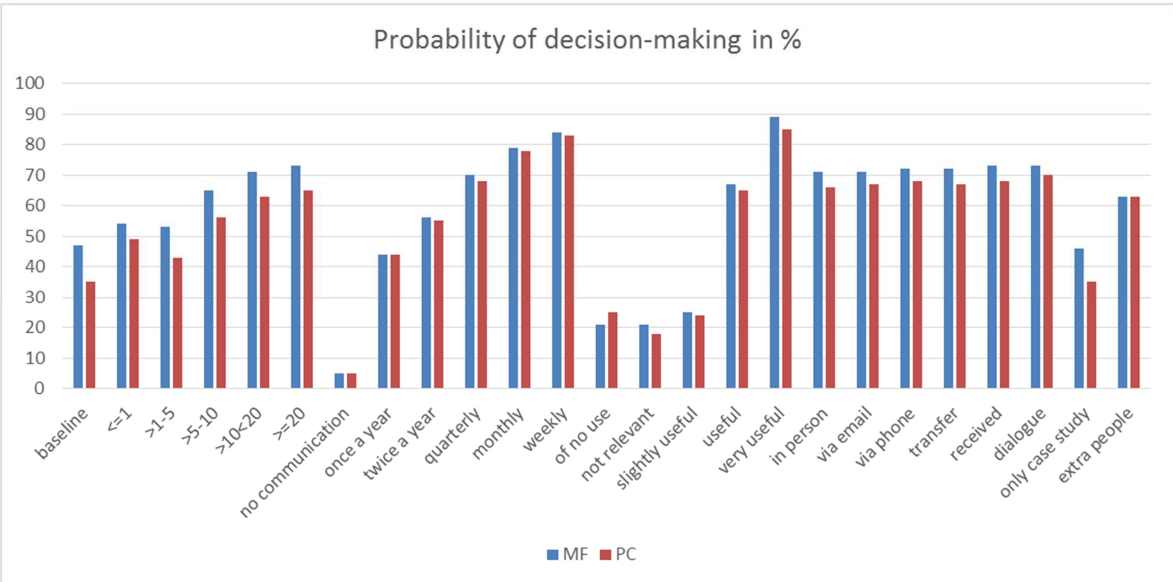


Figure 5. 3 Probabilities for decision-making based on the communication of network actors for all analysed scenarios, comparing results from the Bayesian Network analysis for both case studies: MoorFutures (MF in blue) and Peatland Code (PC in red).

5.2.5 Scenario 3 – Influence of the frequency of communication on decision-making

These scenarios explore how the frequency of communication affect evidence-informed decisions being made. The first finding from this research shows that the probability that decisions are made based on the communication with other actors in the network increases the more frequent they interact (Figure 5.4). The frequency of communication amongst participants increases with increasing duration of the studied relationships. Even for the longest relationships amongst the network actors of 27 years a plateau, where no further increase is recorded, has not been reached.

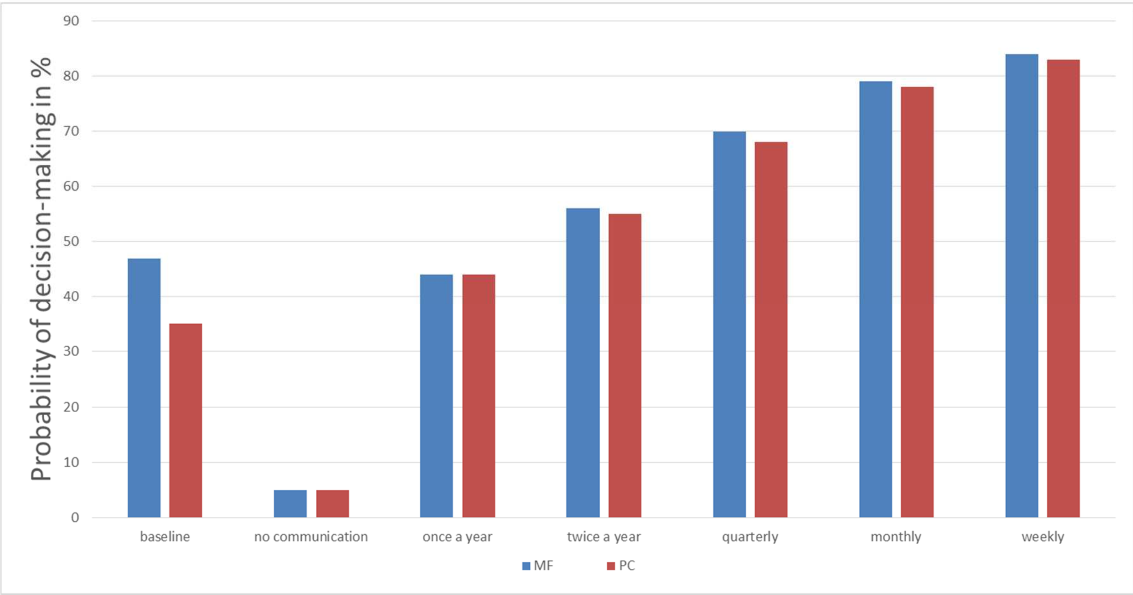


Figure 5. 4 Probabilities for decision-making based on the frequencies of communication amongst the network actors comparing results from the Bayesian Network analysis of both case studies: MoorFutures (MF in blue) and Peatland Code (PC in red).

Compared to the baseline scenario, communication once a year decreased the probability for decision-making in the MoorFutures (MF) study and increased it in the Peatland Code (PC) study. Thereafter a further increase in the frequency of communication resulted in a steady increase in decisions being made. As frequency of communication increased from twice a year to quarterly, an increase for the statement "useful" could be recorded and a very significant increase in the statement that it is a "very useful" communication. If the communication frequency increases from twice a year to quarterly, the same significant trend could be seen for factors: personal communication, communication via phone and email, transfer of and receiving from knowledge and dialogue.

To conclude, the likelihood that decisions were made based communication with other actors in the network increased with increased communication frequency. While weekly or monthly communication may not be feasible for many stakeholders, results show that even quarterly and bi-annual communication is more likely to influence decisions, with communication twice a year leading to a 55% probability in the PC and 56% in the MF case study, that decisions were made and quarterly communication leading to a 68% probability in the PC and 70% in the MF case study.

5.2.6 Scenario 4 – Influence of perceived usefulness of the communication on decision-making

Interview partners were asked to state how useful they find the communication with each of the other actors in their network. The options ranched from "of no use", "not relevant", "slightly useful", "useful" to "very useful". In both case studies the probability that interviewees made decisions based on the communication with the others decreased, if they perceived the communication to be "of no use", "not relevant" and "slightly useful" compared to the baseline scenario. Interviewees described usefulness of communication in various ways, including salience to policy issues, the level of interest to the person receiving information or the importance of being aware of critical perspectives. For example:

> *"No, that was not relevant for my work."*
>
> [M2 on whether he/she made decisions based on the communication about M5]

> *"Honestly it was more like a chat then a discussion about peatlands. […] But I was very pleased he/she was on the Peatland Code steering group, as I had a chance to catch up with him/her a bit better. […] Slightly useful. What he/she does is interesting. Works something with forest."*
>
> [P18 asked about the usefulness of communication in connection with P4]

> *"That is always the question …, if one does not feel heard, then it does not feel useful. But sometimes it is useful to know who are the critics."*
>
> [asked about usefulness of communication. Interviewee wants that quote to be anonymous]

Neither P18 nor M1 made decisions based on the communication with P4 or M10 respectively.

However, the probability for decision-making increased if they stated the communication to be "useful" and "very useful". Responses referring to "very useful" and "useful" included aspects that communication led indeed to decision-making, ensuring that the interviewees work is indeed policy relevant and the reflection that the existing science-policy connection exists. Another interviewee acknowledged that communication with the other person has an impact as he/she spreads the message efficiently. Furthermore, one person highlight the usefulness of the others combined role as scientists and policy administrator, whereas M4 praises the reviews that M5 publishes. M1 on the usefulness with an externally mentioned network actor. M1 seems to perceive the competencies and personality traits of externally mentioned network actor as very useful:

> *"[…] useful communication as they provided some useful info that built basis for choosing a specific site as case study site".*
>
> [P18 asked about usefulness in connection with communication with P2. P18 received information he/she needed and that formed a basis for subsequent decisions he/she made]
>
> *"Useful, otherwise I would not communicate to him/her".*
>
> [M11 asked about usefulness of communication in regard of M7. For M11 communication needs to be of some use or he/she would cease communication]
>
> *"[…] I get a much better understanding of the political drivers and whether the research questions are … that influenced the direction my research has gone, in order to ensure it has policy relevance."*
>
> [P18 on talking to external network actor]
>
> *"It is very useful that this part of communication between Greifswald and the ministry exists."*
>
> [M5 asked about usefulness of communication, he/she responded by referring to a subgroup of scientists from Greifswald [M1, M5, M7, M11. For him/her the existing network connections and exchange is important.]
>
> *"And he/she is a communication vector in MoorFutures, so I see that the information that I provide to him/her, is going places. In that perspective it is also very useful. What do you call him/her – multiplicator?"*
>
> [M5 about M9. For M5 M9 fulfils an important communicative multiplicator role and communication with M9 fulfils a purpose for M5]
>
> "[Usefulness?] *Extremely. Because he/she is sitting and working at the Ministry. He/she is also responsible for some projects. He/she is one of the rare persons in the administration who tries to transfer science, scientific knowledge directly in political decisions. He/she is researcher and administrator."*
>
> [M4 about M2, M4 finds the communication with M2 extremely useful, as M2 has a very important combination of roles bridging directly at the science-policy interface.]
>
> *"Very [useful], because he/she is collecting data and he gives always the state of the art concerning climate regulation of peatlands and regulation*

functions. And this is really important that he/she is … and he/she is always publishing reviews. Getting this information is always helpful.”

[M4 about the usefulness in regarding of communication with M5.]

“Very useful. Very bright guy … practical … yes. He/she can make complex things in science – simple for practice. He/she is still is very useful in the help us think how to make methodology simple. … He/she makes solutions instead of problems.”

[M1 on the usefulness with an externally mentioned network actor. M1 seems to perceive the persons’ competencies and personality traits very useful]

“[…] he/she is a looking forward and therefore the information is getting some thoughtfulness. Because he/she has a different perspective then we have in the administration and from that point – it is very useful.”

[M2 seems to perceive M11’s competence’s as very useful]

If participants perceived the communication to be “very useful” the scenario model shows an increase in the probability to make decisions of 85% for the Peatland Code case study and 89% for the MF study. If people stated that they found the communication to be of “no use”, they transferred more knowledge compared to their perception of actually receiving knowledge in both case studies. This Bayesian network scenario showed a 73% probability that interviewees transferred knowledge versus 35% who received knowledge in the MF study and 62% versus 36% probability in the PC study respectively (see appendix B for the data table). If people had no direct dialogue they were less likely to perceive the communication as being “very useful” (16% for the MF and 31% for the PC study) or “useful” (24% for the MF and 41% for the PC study).

5.2.7 Scenarios 5a-c – Influence of the modes of communication on decision-making

These scenarios look at the actual importance of communication in person (5a), via phone (5b) and via email (5c). For these analysis the target scenarios of 100% probability were set for each of the three options separately. All three scenarios results show, that even if only one of the three modes of communication were used to communicate with a 100% probability target set, the probability to make decisions based on the communication with the other people in the network increases to a 66 – 72% probability compared to the baseline scenario. Probabilities also increase that participants transfer, receive and/or exchange knowledge via dialogue compared to the baseline scenario. Relationships tend to be older compared to the baseline scenario and communication occurs more frequently. Further details can be found in data Table 3 in Appendix C. Participants preference for the mode of communications differ, as is reflected in the following quotes from interviewees:

> *"Mainly in person – we were together in Russia 2-3 weeks - and through email. It is more efficient to send [knowledge about peatland ecosystem services] via email."*
>
> [M2, Scientist/policy officer]

> *"We meet each other, else we call each other up."*
>
> [M6, policy officer for MoorFutures in Brandenburg, about modes of communication with M12, general MF coordinator]

> *„Per phone, preferable per email and regular personal meetings."*
>
> [M3, project coordination of MoorFutures in Schleswig-Holstein, about modes of communication with M12, general MF coordinator]

> [Phone is not yours?] *„No!"*
>
> [M9, communications spokesperson]

> *"All three [media]. Email the least."*
>
> [M1, scientist/political negotiator about modes of communication with M13, politician]

5.2.8 Scenarios 6a-e – Influence of receiving and transferring knowledge versus engaging in a personal two-way knowledge exchange on decision making

Scenarios 6a-c explore the influence of the decision probability, if (6a) knowledge is only transferred, (6b) knowledge is only perceived to be received by the participant and (6c) only exchanged via a two-way dialogue with a target scenario of 100% probability for each of the three options. Scenarios 6d and 6e aim to analyse the consequences of an absence of two way knowledge exchange on the probability of decisions being made, if knowledge is only transferred (6d) or knowledge is only being received (6e).

Scenario 6a Influence of transferring knowledge on decision making

If a person in the MF case study transferred knowledge to another person in the network (here the transfer variable is set to target of 100%), the probability of decisions being made is 72% compared to 47% in the baseline scenario. The results for the PC study are 67% compared to 35% for the baseline scenario respectively. The probability that people knew each other <1 year in the MF study is only 9% and 10% in the PC case study. The majority of network actor under this scenario knew each other for more than 1 year (89% in the MF and 87% in the PC case study).The frequency of communication is higher compared to the baseline scenario. If people transferred knowledge the probabilities to receive and actively exchange knowledge using all three media increase compared to the baseline scenario as well, so does the perceived usefulness of the communication.

Scenario 6b Influence of received knowledge on decision making

If a person in the MF case study perceives she/he received knowledge from another person (received variable is set to 100% probability) the probability of decisions being made increases to 73% and 68% for the PC respectively. People perceive to receive more knowledge the longer the relationship. If people perceive to have received knowledge from another actor the probability that people knew each other <1 year is 9% (10% in the PC) and increases to 34% if connections lasted 1-5 years (34% also for the PC study) and 26% if relationship exists 5-10 years (25% for the PC study) compared to the baseline scenario. Interviewees also state that they communicate more frequently with each other under this scenario compared to the baseline. Overall the result are very similar to the above transfer scenario, the main difference is that actor perceive the communication as “very useful” with a higher probability (51% for MF and 47% for PC).

Scenario 6c Influence of active dialogue about knowledge on decision making

If an interviewee in the MF case study perceives to have been in an active exchange of information and/or knowledge via dialogue (dialogue factor is set to 100% probability) the probability of decision-making increases to 73% and 70% for the PC respectively.

Scenario 6d - transferring knowledge without active personal two-way exchange

In this scenario different targets were set to the Bayesian network analysis: actors transfer knowledge with 100% probability; they are in 0% dialogue; and have 0% probability to communicate in person. This means that a scenario is created were people have no direct personal exchange with another actor, yet they transfer knowledge to them. Given these analysis targets the outcome shows, that with a probability of 51% for both case studies, participants knew each other between 1-5 years. About half of all people state they do not communicate (49% for MF and 50% for PC). Participants are less likely to state that they find the communication “useful” or “very useful”. And given the scenario targets, participants are less likely to perceive to have received knowledge with a probability of 35% (see data Table 3 in Appendix C for further details).

Scenario 6e - receiving knowledge without active personal two-way exchange

Scenario 6e is similar to 6d above, however the target is about 100% probability of receiving knowledge, combined with 0% dialogue and 0% probability to communicate in person. Again this scenario analyses data were participants stated they do not exchange with another actor in person, however they receive knowledge from them. Results for this scenario show that the age of the relationship categories are more evenly spread compared to the previous scenario (probabilities for <1 year = 10%; 1-5 years = 33%; 5-10 = 20%; 10-20 = 14% and >20 = 7% for both case studies). Yet the frequency of communication is still not significantly higher. Actors communicate weekly with a probability of 2% (MF) and 1% (PC); monthly 2% for both case studies; quarterly 15% for both; twice a year 27% (MF) and 26% (PC); one a year 17% for both case studies and 38% (MF) and 39% (PC) do not communicate at all. However there are significantly more people stating that, when they receive knowledge, they perceive the communication as being "useful" (29%) and "very useful" (31% for both case studies) compared to the previous scenario 6d.

5.2.9 Scenario 7 – Comparing case study results with results from people who were mentioned from outside of the studied networks

Interviewees were asked to add additional people beyond their network, that they believe are important for them to exchange knowledge about peatlands and their ecosystem services. The same set of interview questions were asked in relation to those additional relationships (details about the interview questions can be found in chapter 3). Results show higher probabilities for decision making for extra mentioned people compared to the people identified as being part of the case study network. Relationships tend to be older within the group of additional mentioned people. Also, knowledge is transferred and received as well as exchanged via dialogue with higher probability amongst extra mentioned persons. Furthermore, the perceived usefulness statement of "very useful" was mentioned with higher probabilities amongst extra mentioned people, compared to internal network actors in both case studies. While the probability of in person communication via phone and via email increases in both cases increases between the internal and extra mentioned people, the usage of phone in the PC study increases significantly from a probability of 23% to 53% amongst the extra mentioned people.

5.3 Discussion

This chapter addresses the need to analyse the relative importance of key factors for knowledge uptake and to maximise the probability of evidence-informed decision making in policy and practice. It suggests optimal factors in the knowledge exchange process that are most likely to enable evidence-informed decision-making.

5.3.1 How does the frequency of communication influence factors relevant for decision-making?

Frequency of communication is a widely used proxy for trust (e.g. Borgatti and Li, 2009; Levin and Cross, 2004; Prell, 2009; Tsai and Ghoshal, 1998) (see more in section 2.5.5. in the literature review chapter). Publications on knowledge exchange suggests the need for "regular", "frequent" or "ongoing" communication (e.g. Cvitanovic et al., 2018; Durham et al., 2014; Edelenbos and Klijn 2007; Young et al., 2013). However this is not precise enough to be of practical use and the question remains how exactly the frequency of knowledge exchange effects the probability that decisions are made. Results for both the MF and PC case study clearly show that the probability for decision making increases with increasing frequency of communication amongst network actors. Even with an average communication frequency of "once a year", the probability to make a decision based on the communication with the other person in the network increases (see Figure 5.2 in Section 5.2.5 above), compared to the baseline scenario. Furthermore, with further increasing frequency of communication the results show increased probabilities to transfer, receive knowledge and exchange knowledge via dialogue. These findings present concrete examples of what exactly "regular", "frequent" communication means regarding the probability of decision-making amongst network actors. Interestingly, while a dip of decision-making could be observed between years 1-5 of the relationships, this does not hold true for frequency of communication that shows an increase of the probability to make decisions throughout the age of the relationship. This strengthens Edelenbos and Klijn's (2007) hypothesis that ongoing communication is vital for the development of long-term trusting relationship leading to decision-making. The results show a very small probability that people who do not know each other and do not communicate still make decisions. This could partly be explained with one instance where, the interviewee does not know the other person in the network personally, only via someone else, but made a decision based on their publications (more on transitivity trust see 4.3.7 below):

> *"I know him via [person], but I do not have personal contact."*
>
> [M6, Policy officer for MoorFutures in Brandenburg]

Taken all results of various scenarios into account the data suggests that communication with a quarterly frequency or more from the outset and throughout the relationship seems the most effective option to increase uptake of ecosystem service knowledge into decision-making.

5.3.2 The merit of successful reception of one-way transferred knowledge for decision-making

The current literature is full of critique for linear approaches to knowledge transfer (e.g. van Kerkhoff and Lebel, 2006; Koetz et al., 2011; Ward et al., 2012; Watson, 2005). But it is unclear why linear communication is deemed so negatively given that both of the one-way knowledge exchange directions (transfer and receiving) play important elements within two-way dialogue. Results from a survey with international peatland policy makers (chapter 6) show that some participants like to receive specific tailored knowledge products transferred to them in a more linear-way. Current criticism makes more sense if linear communication is indeed only seen as a one-off knowledge transfer without any previous relationship building (Young et al., 2014) and without tailoring the knowledge product to the needs of the target group (other survey participants ask for interactions to clarify needs and identify common goals, see chapter 6). Some stakeholders might neglect knowledge if it does not fit in their current agenda or time schedule or if it does not align with their values (see chapter 6; e.g. Russel et al., 2014).

Combining successful, targeted one-way communication with two-way dialogue is key. The Bayesian network analysis suggests that the secret seems to lie in the successful reception of knowledge. This addresses a gap in the current literature with impact evaluation studies, including analyses of knowledge exchange and stakeholder engagement, just starting to emerge (Posner and Cvitanovic, 2019). During a mere one-way communication, a successfully reception at the target group cannot always be ensured as the one participant reflects:

> *"… it was me standing up and giving a talk about my science which [another person in the PC network] hopefully listened to and then [the person] talked a little bit later on about [it]."*
>
> [P18, scientist]

Even though transfer of knowledge is important for decision-making, an interesting result of this study suggests that the reception of knowledge is even more important. This holds true for the entire duration of the relationship, but is crucial in the time up to year 5 in the relationship (see trust section below). Results from a social network analysis studying the same two case studies (see chapter 4) show that if one person transferred knowledge to another, the other does not necessarily perceive to have received it. Therefore, a regular exchange from the outset is recommended to align expectations and time schedules and to make sure that the produced knowledge is deemed useful and relevant for the purpose of the other communication partner. To ensure a probability that decisions are made based on the communication are beyond 50%, a communication frequency twice a year or more and for during the duration of the relationship according to the data analysis is recommended. If the target person does not perceive to have received knowledge, the probability that decisions are made based on the communication with this specific person is significantly decreased.

In contrast, in a dialogue the chances are higher that the knowledge that is transferred indeed arrives at the dialogue partner. This allows communication partners to seek clarification and ensure the message gets across (e.g. Nesshöver et al., 2016). By contrast, during a pure transfer of knowledge, chances for successful transmission are smaller and stakeholders needs to take other measures to ensure that the successful reception of the message by the target person, such as repetitive transfer of the same message to the target group (e.g. Rogers, 2003, Tinch et al., 2018) via all modes of communication.

Results from this research show that in the scenarios where no dialogue or/and in person communication takes place, one-way communication that leads to a successful perception of receiving knowledge still results in higher probabilities that decisions are made, compared to a scenario where participants transfer knowledge one-way only. Furthermore, in the scenario where people only transferred knowledge, but did not have a personal two-way exchange and/or felt they did not receive any knowledge, network actors stated they did not communicate at all. This even included that they neglected that they transferred information to the other persons at all. If people had no direct personal dialogue they were also less likely to perceive the communication as being “useful” or “very useful”. Perhaps this can be interpreted that without the two-way exchange, they do not see the relationship as trustworthy (yet) and are less likely to make decisions based on it.

The scenario where people only received knowledge, without having a personal two-way exchange transferring knowledge themselves, still shows relative high numbers in the probability of decision-making. This is across all year categories. Interestingly there are significantly more people stating that they perceive the communication as being “useful” or “very useful” compared to the scenario where people only transferred but did not receive knowledge or have been in a personal exchange. This is all while the probability to make a decision based on the communication only increases slightly compared to the transfer-scenario.

Instead of a plateau or decreasing need for exchange of knowledge over time, the data suggests a steady increase in both one-way and two-way communication, all the way from only knowing the other person for less than 1 year, right to knowing them >20 years. This is against the expectation that, the older the relationship, the need and therefore the probability for exchange decreases.

In conclusion, the perception to receive knowledge seems to have a positive effect for the development of a relationship and could be seen as an important ingredient for evidence to be taken into account when stakeholders have been in an active ongoing exchange of knowledge.

5.3.3 Merit of dialogue

Added value of this research lies in the successful knowledge reception part of the knowledge exchange process. The data suggests that an active dialogue, where people listen to each other, clarifying their needs and expectations (see policy makers advice to researchers in chapter 6; and also Laurance et al., 2012, Lövbrand 2011), supports the reception of knowledge. If knowledge exchange is successful throughout a stakeholder relationship actors clarify when and what research outputs are and will be communicated. Hence the target group will be more open and receptive to receive the research results. Hence the likelihood for research uptake and decision-making increases, as stakeholders ensure, through dialogue, the research is relevant for the policy issue at stake and readily applicable (Young et al., 2014).

5.3.4 The influence of the mode of communication

Various literature has proposed the importance of personal communication for achieving uptake of research knowledge and therefore research and policy impact (Reed et al., 2018) and building of social capital increasing the potential for trust (Dietz et al., 2003; Rust et al., 2020). This PhD research looked at three different modes of communication – communication in person, via email and phone. Additional participants mentioned the use of twitter and Skype to communicate. The probability of the independent use of all three modes of communication increased with increasing length of the relationship and does not show a plateau in the year category >20 (see Figure 5.2 for distribution of the length of relationships).

In a scenario where participants stated that they had no dialogue with each other, but still had personal communication, this led to a higher probability for decision-making compared to the use of the other two media – phone and email. This may highlight the importance of small talk for the development of trusting relationships as described by the following study participants:

> *"I believe there would be far more impact, if one would know each other better. I meet them once or twice a year, but actually I do not really know them. So on a level – how did you got into the peatland topic? What is it that effects you personally? I know that perhaps for two or three."*
>
> [M9, communications spokesperson]

> *"If I had any recent communication with [person] then it would about rugby. [Person] is a big [club 1] fan and I am a [club 2] fan and we had a very good session […] years ago. But what [person] does on the Woodland Code is of great use for the Peatland Code. So I had useful conversations about that with [person] in the past. I am keen to talk to [person] some more via the Peatland Code group [in the future]."*
>
> [P18, scientist]

The merit of informal exchange is also mentioned by a survey participant in chapter 6 of this thesis. Furthermore, while engaging in personal exchange stakeholder can ensure that they align each other's' needs and once research results are analysed the outcomes can be tailored accordingly, increasing the likelihood that is will be successfully received by the target group. In the Bayesian network scenario 5a without personal communication (see data in Appendix C), people do not compensate this with increased communication using other media. This again highlights the importance of personal communication, not only for decision-making.

Based on the research findings, it is possible to propose the use of interpersonal communication as a proxy for trust and effectiveness of knowledge exchange and uptake, as this aligns with an increasing probability for the following factors: decision-making, transfer via two-way combined with one-way communication as well as increasing likelihood of "very useful" communication. For example, one participant from the MF study implied some level of trust when they said:

> *"I know [persons'] mobile number."*
>
> [M7, scientist]

The person continued to mention, that he/she also had the mobile number of another person in this network and called them directly if necessary and urgent. The two relationships he/she referred to were between 10-20 year and more than 20 years old respectively.

5.3.5 Usefulness variable

As it was expected the more "useful" the participants described the communication the higher the probability of this person that this person makes a decision. The highest probabilities for all compared scenarios of decision-making maximisation can be observed with 89% in the MF project and 85% in the PC project. Furthermore, if interviewees described the communication as "very useful" the highest probabilities for one- as well as two-way knowledge exchange and usage of all modes of communication were observed.

If interview partners perceived the communication with the other person to be "of no use", probability of making a decision is relatively low. Even though participants still transferred knowledge with relatively high probabilities under this scenario: 73% in MC and 62% in the PC study, they only perceived to have received knowledge with a probability of 35% in the MC and 36% in the PC study. This might suggest that people need to feel they actually received something from the other person before they find it useful. This is in line with the other factors affecting and having an effect on the reception of knowledge (see scenario 6b in 5.2.8 and 5.3.2 above). Alternatively, there might be interpersonal barriers that led the interviewees to state they have not received knowledge, which might be based on a perception only, as the other person might have transferred something nevertheless. However, given that participants transferred knowledge with a relatively high probability, these actors might actually invest specific effort into the exchange with the other network actors and are motivated to get their knowledge across. This is backed up with the data showing that these actors have been in a dialogue with a relative high probability as well as being involved in communication in person, via phone and via email. The following quotes shows that efforts were made by the group and that it took them considerable time to successfully transfer their message to a target group:

> *"Regarding the standard. With [person] from [institute] it was a challenge to make it clear to [the person] that our approach is reliable, and is really thought through We now managed to get closer, that the carbon is compensated, but it is unsuitable to market it as climate neutral." […] "And this is, where it took us a long time with [the institute]. To make it clear to them."*
>
> [M9, communications spokesperson]

This is in contrast to the scenario where interviewees stated the communication with another actor to be "not relevant" for them. Again, the probability to make a decision is relatively low (21% for MF and 18% for PC), so is the actors' perception to have received knowledge from others. The difference to the above is that the effort to transfer knowledge is lower compared with the above mentioned "of-no-use"-scenario. The overall motivation to engage in knowledge exchange with the referred actors is low.

It is interesting in the "slightly useful" scenario that the probability actors know each other less than a year is 21% for both MF and PC. This is relatively high in comparison with the other scenarios. Relationships between 1-5 years have the probability of 38% (MF and PC). This might be explained with the hypothesis that these actors are still in the trust building/developing phase and need to prove their trustworthiness to each other. In comparison people who stated the communication as being "useful" had relationships that were older compared to relationships in the "slightly useful" scenario.

Statements of usefulness could support evaluation of successful research and knowledge exchange impact, with the aim to increase probability of decision-making. If one wants to back-track decision probability and use questionnaires for evaluation of knowledge exchange processes, statements of usefulness could be compared with statements as to whether or not they made decisions. Analysing data with a Bayesian network analysis could compare probabilities that decisions are made under each usefulness scenario.

5.3.6 Strong bonds to people outside the network

A further interesting outcomes is that people who were mentioned to be essential for the interviewees regarding knowledge exchange about peatland ecosystem services were often beyond the closed case study networks.

> *"If I shall name someone else, then [name of person]. And I know the [the person] very well, of course. [The person] initiated a lot here. Also that is all came to it. I also know [person] personally. [Interviewer: How often do you communicate with [the person] now?] More in the past, now not at all. After all [the person] got the whole thing going into the right direction, leaving carbon in the ground. But the whole approach, which originated in the climate debate, yes, [person] set impulses there. And actually the importance for peatlands as buffer, as carbon sink. No one said that before."*
>
> [M6, Policy officer for MoorFutures in Brandenburg]

More decision-making takes place with the extra mentioned people outside the case study networks compared to the people identified as being part of these networks. These relationships tend to be older in comparison too. Furthermore, knowledge were transferred more and also perceived as being received. The same was found to be true for a knowledge exchange via dialogue. The literature backs this data by saying that in times where specific information and access to evidence is sought people turn to trusted peers (who might be more similar to each other – homophilic in various aspects) and intermediaries (Tseng 2012; Reed et al., 2018), including scientists (see chapter 6). People are always part of different networks and the studied case study networks are professional rather than self-chosen friendship network. The results for the extra mentioned people strengthen this further by showing a higher probability in "usefulness" ("very useful"), "decision", more frequent communication, use of all media (except phone for MF case study, whereas the usage of phone in the PC study increased significantly from a probability of 23% to 53% in connection with the extra mentioned people).

There are different possible interpretations for this: i) that the networks may not be as cohesive, well connected and strong as they could be (see chapter 4 for more on the role of central network actors for the connectivity of a network) due wrong selection of actors (e.g. Reed et al., 2018); ii) there might be key individuals missing from the network who could contribute more strongly to decision-making; iii) both networks have access to highly relevant external expertise due to the broad networks of its members and bring in their expertise when needed and/or iv) there might be strength of self-chosen friendship-like homophilic relationships versus the potentially heterophilic professional network relationships predetermined by the coordinators of each of the two case study networks. There are natural reasons for choosing homophilic relationships build on similarity (Rogers, 1995; McPherson et al., 2001; Rust et al., 2020), but ideological selection of peers in networks might lead to a "fracturing of evidence" (Reed et al., 2018). To stay innovative a break up of homophilic group thinking is required according to Granovetter (1973).

In conclusion relationship building is not wholly dependent on existing professional networks, but includes pre-existing network connections. These pre-existing network connections can be important for the development of strong stakeholder interaction at the science-policy interface (Durham et al., 2014).

5.3.7 Decision-making, trust development and effectiveness of knowledge exchange over the duration of a relationship

Previous studies have suggested that trusting relationships evolve from social interactions (e.g., Gabarro, 1978; Gulati, 1995; Granovetter, 1985). As two actors interact over time, their trusting relationship will become stronger (Gabarro, 1978). Prell et al. (2012) adds to this notion, when they state: "Role of trust in exchanging relationships is large" (p. 63). As stated above results show that overall the probability of decision-making increased with the length of the relationships. With the exception where decision-making probability in the year category 1-5 is lower compared to the probability of decision-making amongst the categories of people who know each other up to one year and >5 years. This is the case in both case studies.

Further conclusions relating to trust has are based in inferences made from proxies, rather than based on direct questions about trust. Established proxies (frequency of communication, length of relation, strength of the relationship tie and centrality, see sections 2.5.3 and 2.5.5 for more details) were chosen rather than asking directly about trust on the basis of former research showing that stakeholders are often unwilling to engage in studies asking directly about their level of trust in individuals in their network, as this is highly sensitive.

If the used proxies hold true, this study proposes the combination of the variables "decision – yes/no", length of relationship and variables for knowledge exchange as a combined proxy for trust. The data suggests a strong connection between these variables. By analysing current literature two different scenarios for the starting point of trust are proposed: the initial instant perceived trustworthiness while interacting with another stakeholder that need to prove itself over repeated interactions (Chang et al., 2010) and a non-zero starting point reflecting the engagement based on individual and institutional reputation and credibility (in line with Lacey et al., 2018) and transitivity trust, which means that if one actor (or institution) is seen as trustworthy, people they trust will be trusted as well (Henry and Dietz, 2011) even if they have never met before. Data from this study suggests that the critical time to prove trustworthiness to be the years 1 to 5.

Data from this study may suggest that the critical time to prove trustworthiness to be the years 1 to 5. If the data interpretation of this critical time and the proposed proxy holds true, this is in contrast to the four suggestions of trust development in the perspective piece by Lacey et al., 2018. Comparing data from this research with the ideal trust development scenario as proposed by Lacey et al. (2018), none of the four scenarios proposed by the authors include the critical phase of trustworthiness, which might be interpreted from the proxy derived data from this research. Lacey et al. (2018) theoretical study results indicated that trust increased to a "trust plateau". This could also not be observed based on the analysed relational data until year 27. However, given that these results are based on only 15 pairs that have relationships >20 years, these results need to be interpreted with caution. For the development of trust Lacey et al. (2018) suggest to manage expectations from the outset. Face-to-face communication is seen as an important first ingredient in developing trust in networks (Rust el al., 2020). Furthermore, for trust to develop relationships need to last for longer time frames, than (political) terms (see quote from P18 below). The two quotes below describe the difficulties of developing relationships during times of frequent staff turnover:

> *"Problem with [institute] is that they have quite a lot turnover of people doing particular jobs […] So I had a very good interaction with [persons] predecessor,*

but [person] moved on to other things. I have not managed to rebuild this link with [new person] yet."

[P18, scientist]

"[Person] is one of the few people in government that has not moved to something else in the last ten years. [Person] is interested in soils and [person] is very supportive and [person] holds a great deal of institutional knowledge. The turnover in government is one of the biggest problems we have. I mean I used to do a lot of work on air pollution impacts … they had different member of staff running their resort every year for about 6 or 7 years. It was impossible … you spent half the time, almost, trying to educate someone on why you are doing the work that you are doing … and now eventually they understood what you were doing: 'Now, I see what you are doing. That is useful.' and then they leave. I lost interest myself lots of the time. […] Nothing in government is really changing, because there is no one there that understands."

[P18, scientist]

Long term trusting interpersonal and inter-organisational relationships are therefore key for effective science policy interactions (Reed et al., 2018). In conclusion trust in social networks can lead to more meaningful communication that leads to more people stating they make decisions based on the knowledge exchange they are having with each other (as shown by the data from this research).

5.3.8 Comparing the case studies in the UK and Germany

The case study approach allowed results to be compared and contrasted in relation to different settings (Yin, 2003). Overall the German MF case study had longer relationships, higher communication frequencies, more one-way and two-way exchange, higher usefulness statements, more use of in person, communication via email and especially phone as well as higher overall probability to make decisions compared to the UK study. Furthermore, in the latter more people do not know each other within the network. All of the above might be for several reasons: the relative shorter duration of the PC development and the more distributed physical workplace locations of the actors made it more difficult to meet up in person. Workplaces were spread further apart in the UK case study compared to more regional spread of workplaces of MF actors. Phone conferences did not make up for this and participants often could not recall who was present in these meetings. Additionally, the PC network contained more actors compared to the German MF network (20 and 14 actors respectively). The shorter duration of the PC could also explain why relationships tended to exist longer amongst MF actors. However there are also people on the PC network who know each other >20 years too.

In conclusion, three main factors influenced the differences of analysis results from the two case studies: the duration of the project; the length of the relationship and size of the network.

5.4 Evaluation of the methodological limitations

The use of BNs in the study of decision-making is well established (e.g. Watthayu and Peng, 2004; Sierra et al., 2018). Hence this study represents an application of this method in a new context, to better understand factors influencing decision-making in two science-policy networks, enabling the exploration of new world views without having to manipulate subjects or conditions. BN was used to examine the relative importance of factors (chosen on the basis of evidence from literature – see literature review chapter 2), enabling knowledge uptake and evidence-informed decision-making to serve conservation and its multi-disciplinary application suitability has thereby been extended. A major positive aspect of this work is the in-depth multi-method analysis of two case studies that enabled a comparison. However this approach is limited because it represents only one snapshot in time. The analysis is only able to analyse participants' answers reflecting their perception of the communication at the moment of the interview and therefore all interpretation of these results must consider that interview partners were asked to consider their answers about their personal knowledge exchange during the past year prior to the interview. The BN technique did not lend itself to provide an in depth perspective on power relations. However betweenness centrality measures from the SNA (chapter 4) gave insights on who holds power to diffuse knowledge or not and therefore hold power (Bodin and Crona, 2009; Prell, 2012; Schiffer and Hauck, 2010). Some further insights were gained on the role of power dynamics from qualitative data for example regarding group decision making amongst equals, (section 4.2.2). Another factor that was difficult to analysis via BN methods is the aspect of group decision-making versus decision-making in a dyadic exchange. However this is where the strength of my mix-method choice comes in, as these aspect were covered in the additional qualitative material about decisions (section 4.2.2). As the quantitative part focussed on two-actor relationships only, the additional qualitative data revealed that this does not capture the relational approaches that lead to decisions being made in groups. Furthermore, quantitative answers were therefore not able to shed light into all trust building incidences that happened in years prior to the interviews being conducted, unless they were particular mentioned in the provided qualitative information as described in the results section above.

5.5 Future research steps

As no specific knowledge broker was part of the networks that were studied from the outset – M9 [communications spokesperson] only joined the MF network two years prior to the interview - it can only be speculated if the quality of exchange and trust building could have been improved. Further research could evaluate the impact that intermediaries such as knowledge brokers might have towards increased decision-making and how they are/were able to support the knowledge uptake and relationship building enhancing the perception to receive knowledge by moderating, facilitating as well as mediating the different perspectives of all stakeholders. Stakeholder engagement from the outset of a project and involvement over time ensures the alignment of expectations (Lacey et al., 2018) and is valuable in creating a common vision and common goals (Bielak et al., 2008). Or if there is indeed a chance for a successful inclusion of a knowledge broker at a later stage in the project, ideally before trust is broken or at least as soon as misunderstandings become apparent as the case in MF project.

As results show that the probability of decision-making increases with increasing perceived usefulness of the communication, future evaluation research and practice could look into the potential to use the analysis of "usefulness" answers in surveys to make predictions of decision-making probability during evaluations of knowledge exchange. Furthermore, research should look into trust development over time to see if it could either back findings from this research, enhance or reject them. Future work can also look at case studies from other topics/fields of study to allow for further cross-sectoral comparison.

5.6 Summary and conclusion

This research identified key factors that improve the probability of decision-making and knowledge uptake at the science-policy interface and beyond. By doing so the research is able to respond to a call to look closer into how trust is developed and maintained (Boschetti et al., 2016; De Vries et al., 2014) over time in a relationship between stakeholders. However, interpretation and conclusions of the trust data should be viewed with caution as they are based on proxies of trust (see further details of these proxies: trust in connection with centrality, frequency of communication and therefore strength of the connection, the literature review chapter 2 and sections 2.5.3 and 2.5.5 in this thesis). If the interpretation of the critical time in year 1-5 based on the proposed proxy holds true, this is in contrast to the four suggestions of trust development in the perspective piece by Lacey et al., 2018 and might not grow steadily in the early phases of a relationship or plateau over time.

Results provide important insights into knowledge exchange within two closed case study networks. Both MF and the PC are dealing with payment for ecosystem service schemes for peatland restoration.

Based on the findings from this chapter, key factors can be recommended for maximising decision-making over time include:

- Frequent communication amongst stakeholders, ideally quarterly communication over the entire time of the relationship (including relationships lasting >20 years) using all modes of communication
- ensuring that knowledge is received by the target group, ideally through personal communication
- awareness of the potentially critical time for trust-building in the years 1-5

It is clear that effective communication at the interface between biodiversity research, policy and practice is important to ensure that evidence is taken into account for environmental policy-making and furthermore that functional trusting relationships are vital in doing so. Results not only infer lessons for researchers communicating with members of policy and practice, but provide a basis for improving communication and knowledge adoption and implementation strategies at science-policy interfaces in the field of ecosystem service conservation and beyond. The next chapter elaborates the policy makers' perspective of knowledge exchange and what helped them to develop trust.

Chapter 6 - Successful knowledge exchange and trust development: policy maker perspectives on the international peatland science-policy interface

6.1 Introduction

The previous two chapters looked at science-policy communication and knowledge exchange using two case studies in which researchers and stakeholders from policy and practice were collaborating around Payment for Ecosystem Service schemes in UK and German peatlands. Worldwide only a very limited number of policy makers exist who deal with peatlands – and usually this is alongside other environmental governance responsibilities. The numbers of policy makers dealing with payment of ecosystem service schemes of peatlands are to my knowledge less the 10 world-wide, most of whom I had interviewed previously. To put these findings in a wider global context, and provide more generalisable findings, this chapter looks at science-policy communication from the perspective of the global peatland policy community. The international coverage and broader focus on peatlands therefore increased the sample and allowed me to address the peatland science-policy focus of this thesis. I aimed the questionnaire towards a global coverage. Furthermore, so far research has focussed more on evaluating knowledge exchange from the perspective of researchers, whereas the policy makers' perspectives on knowledge exchange at the science-policy interface is less well studied. Therefore, the objectives of this chapter are to:

1. Analyse policy makers' perceptions of successful knowledge exchange at the science-policy interface
2. Formulate recommendations for researchers to exchange knowledge successfully with policy-makers, increasing the likelihood that research informs decision-making and supports the development of trust.

6.2 Methods overview

To address these objectives, this study collected perspectives of international policy makers who are responsible for peatland policies from local to global scales. A detailed methodology for this questionnaire can be found in chapter 3. To recap briefly here, an online questionnaire was distributed to 650 contact addresses from international policy makers, defined as working for international policy organisations (e.g. national Governments and UN agencies), who were identified first via an initial stakeholder analysis together with the well connected peatland expert Hans Joosten, a relevant stakeholder himself and key network contact for international peatland actors. Further contacts from Ramsar, UNFCCC and REDD+ enriched the questionnaire distribution list. I sent the questionnaire to Ramsar CEPA National Focal Points, UNFCCC Focal Points and REDD+, who are nominated in any country that signed up to these agreements. Hereby policy makers from every country which has peatlands were contacted. The short questionnaire included 11 questions, including six closed answer questions and five open-ended questions. The questionnaire was trialled with the IUCN UK Peatland Programme, and amended based on feedback prior to being sent to the sample group. The questionnaire started first with general questions, to clarify if they were indeed in the target group of policy makers that make or made decisions on peatland ecosystems and what country they are from and what institution they are working for. In line with the research objectives, policy makers were then asked: what helped them to gain trust during interactions with researchers; how often they engaged with them; and what advice they had for researchers engaging with them. The full set of questionnaire questions can be found in Appendix D.

6.3 Results

Results from this chapter provide valuable insights into policy makers' perspectives on effective knowledge exchange and therefore help to understand how and why they consider to utilise research knowledge or not. Evidence is provided on what leads to trust in research. Successful knowledge exchange at the interface between research and policy makers plays an essential part in tackling pressing environmental issues of our time. The chapter therefore concludes with a set of recommendations from this research for policy makers as well as for the research community.

6.3.1 Sample characteristics

In total 37 completed questionnaire responses were received. Of these 25 of the respondents stated that they are or were responsible for peatland policy. Of the 12 responses that stated that they had no peatland policy responsibility: five were excluded from the analysis, due to not being policy makers; one had to be partly excluded, because they engaged with policy stakeholders but their answers did not relate to peatlands; and six replies were included, because, all of these respondents were identified as policy makers with links to peatlands, despite not having peatland policy responsibility, for example one of these was working with a focus on wetlands. A total of 32 responses from international policy makers were analysed.

Questionnaire participants were from 19 different countries covering four continents, but did not cover South, Central or North America. 10 out of 32 respondents answered that their work context is local, 24 national and 13 international (multiple answers were possible) (see Figure 6.1). Furthermore, two respondents added that their work context also includes federal states and one respondent noted their work as covering "everything".

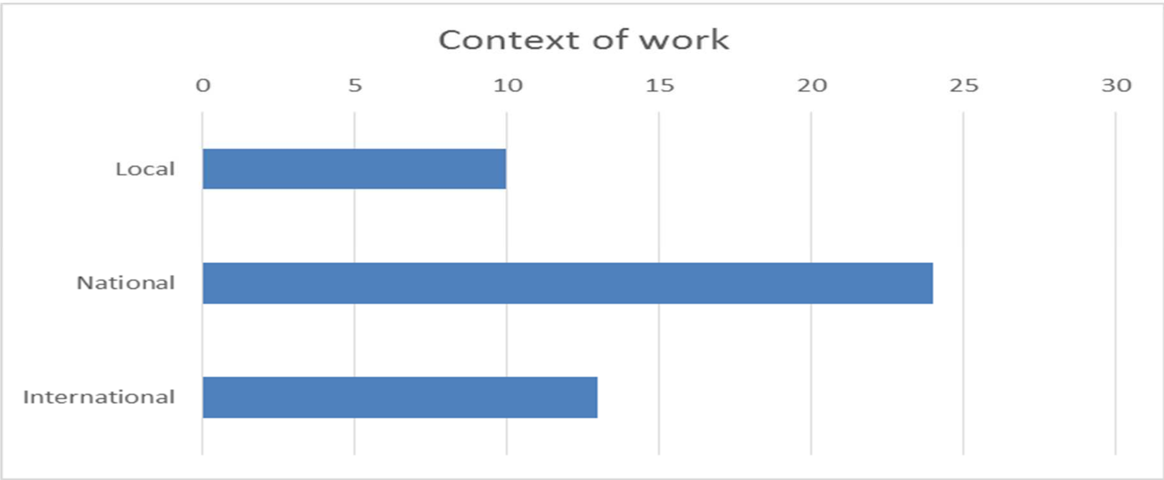


Figure 6. 1 Work context of the participating peatland policy maker.

The communication with researchers refers to the questions asking respondents to describe a recent decisions that the policy makers made based on communication with researchers. This was done via an open question and did not specifically asked survey respondents to describe the researcher they interacted with – particular due to time constraints. Therefore, these could include anyone the policy makers viewed as a researcher - ranging researchers from Universities, research institutes, think tanks or other organisations.

6.3.2 Sources of knowledge

Participants were asked where they sourced their knowledge from to inform their decision-making (see figure 6.2). 31 out of 32 respondents received knowledge from researchers, 22 from colleagues within their institution, 20 from policy makers, nine from the public, nine from the media, three from friends and none from their family. Multiple answers were possible. Further specified sources of knowledge were mentioned and included: "local people in or nearby peatland areas" (S37, works for UN-FAO), "local communities especially resource users" said S16 from the Ugandan Wetlands Management Department, technical reports (S36, who works for the Department of Range Resources Management, Lesotho), for example reports from the Nordic Council of Ministries and the Ramsar convention are important for S14, who works for the Ministry of Climate and Environment in Norway, reports from consultants were mentioned by S24, who works on water management for a Federal Ministry in Germany, own PhD research knowledge and experiences (S32, works for Department of Environment, Land, Water and Planning, Australia), scientific literature and studies (S24, who works on water management for a Federal Ministry in Germany and S29, who works for the Greifswald University, Greifswald Mire Centre – both in Germany and the International Mire Conservation group), civil engineers (S21, from the Scottish Natural Heritage), industry (S18), non-governmental organisations (S18) and public bodies for S2, from the Scottish Government, United Kingdom.

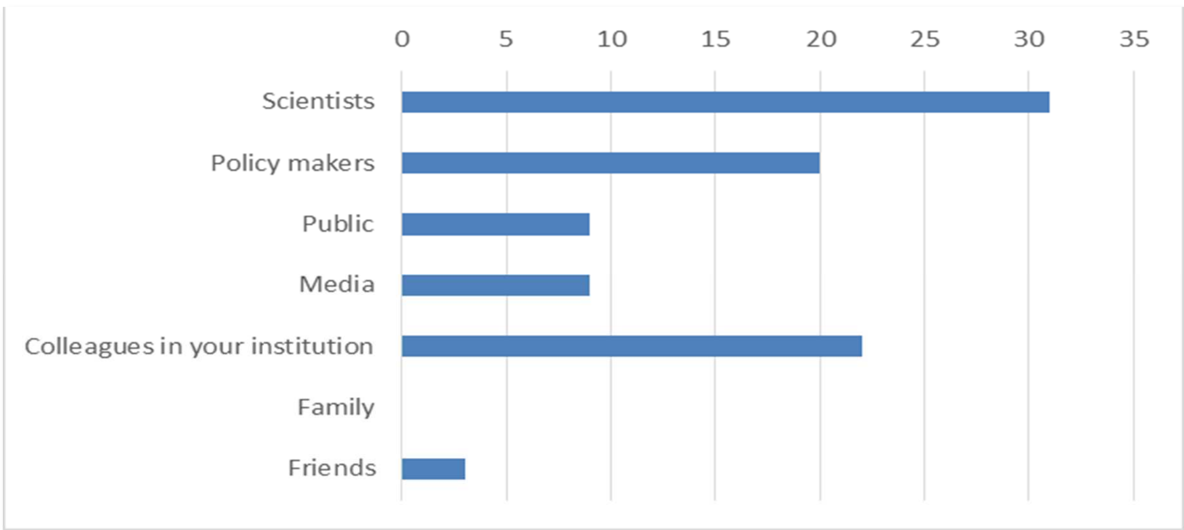


Figure 6. 2 Policy makers' knowledge sources that build the basis of their decisions.

6.3.3 Descriptions of the decisions that policy makers made based on communication with researchers

Policy-makers described their decisions in a variety of ways. In one case, the decision, based on communication with a researcher, was to undertake a "further study on the contribution of peat to carbon sequestration" (S16, works for the Ugandan Wetlands Management Department). The rest of the decisions were related to policy and practice, rather than just to study the issue further. Of these, the majority of decisions (23) followed evidence. Only one decision was made to ignore evidence, in this case, "not to use a suite of species habitat suitability models that were developed for terrestrial systems", stated S32 from Department of Environment, Land, Water and Planning in Australia. 11 decisions related to the themes of planning, developing and designing or registering. For example based on the communication with a researcher, respondent S22 (Ministry of the Environment in Madagascar, who makes local and national decisions) made a decision to register the Barren islands as Ramsar sites and S8 (who works for the General Directorate for Environmental Protection in Poland) to designate a specific regional mountain area in the Carpathian as a Ramsar site. Furthermore, restoration and management plans were developed and finalised (S5, Germany, S28, Netherlands, S33 and S34 from Australia) based on interaction with researchers. S26 (who does local, national as well as international peatland work for the Danish Nature Agency) made a decision to "[design] a demonstration site for kick starting sphagnum growth on former grassland" and S27, from the Department of Agriculture, Forestry and Fisheries in South Africa, stated that he/she made a decision to develop an agro-forestry strategy. Five decisions were made regarding new policy development: recommendations for decarbonisation targets for peatlands (S1, from Wales, UK) and recommendations for new policy concerning peat extraction (S14 from Norway, who works on national and international level); the development of a new national strategy for Nepal for the next six years (S17 works for the Ministry of Forests and Environment in Nepal), a regional climate change plan (S2 from Scotland, UK) and a national adaptation and mitigation plan (S27 from the Department of Agriculture, Forestry and Fisheries in South Africa).

6.3.4 Useful aspects of the communication that lead to decisions being made

The major theme running through useful communication aspects with researchers from a policy makers perspective deals with the reception of relevant, useful, straight forward information and new knowledge, including usable results. This theme featured in two third of questionnaire responses. Further replies go into more detail of the specific aspects of communication. Policy maker find it useful if the researchers' communication is "tailored specifically for [their] needs, so the outputs were ready for [them] to use" (S32, Department of Environment, Land, Water and Planning, Australia). For example, questionnaire respondent S22 from the Ministry of the Environment in Madagascar emphasised that "communication must be clear, precise and faithful to reality" and should draw on "good data" (S24 from a Federal Ministry in Germany), convincing and proven evidence (S27 from the Department of Agriculture, Forestry and Fisheries in South Africa), or confirms other [non-scientific] evidence said S21 from the Scottish Natural Heritage, UK, and previous experiences (S6, S34). Questionnaire respondents S6 (works for Republic of the Marshall islands Environmental Protection Authority) found the recommendation of his/her interacting researcher useful, whereas S3 (works for Defra, United Kingdom) drew on "expertise from a trusted source" and S31 (works at a German Ministry) said the "communication with the researcher(s) is always useful".

Participants described various different modes of communication as useful, some pointed to workshops and conferences, e.g. S17 from the Ministry of Forests and Environment in Nepal, others to telephone calls and email (S5, works for Federal Environment Agency, Germany). S27 (from the Department of Agriculture, Forestry and Fisheries in South Africa) stressed that the amount of meetings you have with stakeholders is important. Useful formats of knowledge and data included e.g. summary/review of existing scientific literature (S14, S21), quantitative data (S1, S2) delivered in spreadsheets (S5) and an "overview of most important issues and gaps at the country level" (S37, works for UN-FAO).

Policy makers liked being kept informed research progress (S35, works for Landcare Research, New Zealand), including (preliminary) results (S9, S16, S24). This helped them to build "similar level of background knowledge between interlocutors …" (S8, who works for the General Directorate for Environmental Protection in Poland) and find common ground (S36, who works for the Department of Range Resources Management, Lesotho). Participant S25, from the Institute of Environmental Protection – NRI, in Poland, found it useful to have "[d]iscussions, defining concrete goals and achieving consensus or common grounds", particular during the review period of policies said S27 from the Department of Agriculture, Forestry and Fisheries in South Africa. S35 from Landcare Research, New Zealand found it useful to integrate various disciplines. Based on the received knowledge and information participant S4 (works for the Royal Government of Bhutan) was able to "… align [their] research with national program". S4 and S26 have "the fundament for the decisions to make".

6.3.5 Least useful aspects of the communication that lead to decisions being made

This section draws from 30 quotes reflecting on communication aspects that policy makers found least useful in the decision-making interaction with researchers. The major theme that emerged refers to aspects where the policy makers' needs were not addressed. This theme received 7 responses and included questionnaire participants S4 (Royal Government of Bhutan) and S37 (UN-FAO) stating that from their perspective the researcher had a wrong focus or scale, as research focussed on a specific area instead of the national scale and focussed on developed countries, instead of developing countries.

Five responses referred to a published journal article (S17 from Nepal) or a general communication with the researcher as being too technical (S2, S9, S35) or detailed (S9, S28). Six further questionnaire replies addressed issues regarding research not being ready for application (S16, S35). The reasons for this included mismatch in scale and focus (S4, S37) and the difficulty "of doing a cost benefit analysis to guide [the policy makers] next step", said S32, who works for the Department of Environment, Land, Water and Planning in Australia. According to S14, who works for the Ministry of Climate and Environment of Norway, the researchers were reluctant to draw conclusions by explaining the lack of research. Respondent S24, who works on water management for a Federal Ministry in Germany, also referred to remaining uncertainties due to "further detailed questions, which [they] [could not] answer [at this point in time] and which inhibit[ed] the implementation of solutions." Whereas policy maker S16 from the Ugandan Wetlands Management Department missed general clarity of the applicability, S5 (works for Federal Environment Agency, Germany) specifically mentioned the missing explanation of the data that was provided to them.

6.3.6 Frequency of communication with this researcher

Frequency of communication between policy-makers and researchers varied considerably, and policy-makers emphasised the need for flexibility in the frequency of communication depending on their needs at the time or the nature of the issue being explored (S16, S25, S34, S35 and S36). Therefore, frequency could vary from daily (S12, Wetlands International), weekly to "communication after several months" (S36, Department of Range Resources Management, Lesotho). Only respondent (S20 from the Papua New Guinea Forest Authority) stated it was the first contact with the researcher. One respondent stated an interaction with the researcher once a year, six respondents had interactions twice a year, eight quarterly, and a majority of 11 respondents had either monthly or fortnightly communication frequencies (see Figure 6.3). Respondent S29 (who works for the Greifswald University, Greifswald Mire Centre and the International Mire Conservation group) mentioned that his/her decisions were made from multiple interactions with various people and that [his/her] "decisions are normally not based on exchange with only one researcher, [he/she] ha[s] daily exchange with many researchers that shape [his/her] decisions." (see more on group decision-making in 5.2.10).

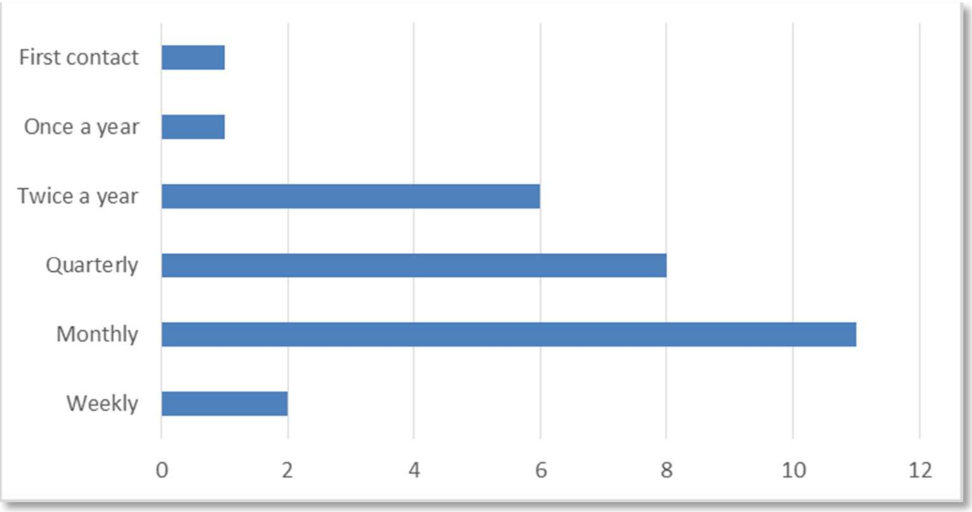


Figure 6. 3 Frequency of communication with the researcher.

6.3.7 Interactions with a researcher/researchers that has decreased or increased participants trust in research

Interactions increasing trust

Respondents described 27 interactions that increased and 22 interactions that decreased their trust in research. First respondents stated that their trust in research increased due to direct interactions with the researchers: through informal exchange (S37, UN-FAO), joint workshops/meetings (S36, Department of Range Resources Management, Lesotho and S37) and even meetings and discussions in the field (S36). S25, from the Institute of Environmental Protection – NRI, in Poland, emphasised that the meetings and workshops that increased his/her trust in research had a limited number of attendance. S34, who does local peatland work in Australia, described the multi-disciplinary project he/she took part in that enabled his/her understanding of a specific local peatland context. S21 from Scotland stated that his/her " ... trust in science will not be influenced by interactions with one or a few researchers", indicating that multiple interactions with multiple stakeholders are important to him/her to form trust and make decisions.

If the researcher focussed on peat and peatland this also supported S13 (works for the Norwegian Government's International Climate and Forest Initiative) and S17 (works for the Ministry of Forests and Environment in Nepal) to increase trust in research. S13 specifically described that his/her trust increased via multi-stakeholder interaction as the "action of Wetlands International, CIFOR and others who have been able to place peat on the agenda of the UNFCCC". Furthermore, respondents described increasing trust due to interactions with researchers that demonstrated an “openness” (S16 from the Ugandan Wetlands Management Department) and “willingness to work and solves issues together” (S35 from Landcare Research, New Zealand). S5 (works for Federal Environment Agency, Germany) describes that the project he/she has been invited to, included “stakeholders in developing relevant research questions and effective communication strategies of usable results”. S8 (works for the General Directorate for Environmental Protection in Poland) described the interaction should be a “timely and accurate response” and S27’s trust increases due to a “monthly report that the Department receives now”. S27 works for the Department of Agriculture, Forestry and Fisheries in South Africa.

For S32, from the Department of Environment, Land, Water and Planning in Australia, it was important “that researchers are able to explain their methods and approach for validation of results”. This statement is backed up by multiple other respondents who say that “well-funded information” (S28 works in the province in the Netherlands), “solid arguments” (S18), “good monitoring data” and “data based suggestion for adapting policy” (S24, works on water management for a Federal Ministry in Germany) increased their trust in research. S12 (works for Wetlands International) described the trust building interaction as being “the impact that [they] had by backing up [their] key messages with sound scientific publications …”. Through the interaction with researchers S9 (who worked on national and international peatland matters for the Government in South Africa) received “guidance on substantive issues that were discussed under the UNFCCC”, which led to increased trust in research.

Trust also increased by providing clarity, comprehensibility (S2) as well as specifically clear and well justified methodology (S22). S22 from the Ministry of the Environment in Madagascar developed more trust as the limitations of the research were clearly communicated. S3 (who works for Defra, United Kingdom) explained that the interaction with researchers built an evidence base had increased his/her trust in research. S4 (works for the Royal Government of Bhutan) simply stated that the interaction with the researcher confirmed a general “willingness to do research”. As the interactions lead to research outputs (S1, works for the Welsh Government, United Kingdom) and were published [in] scientific papers and articles (S11) trust in research increased amongst S1 and S11. And finally S30 [works at Ministry of Water in Lesotho] stated that his/her interaction led to decisions, as “it increased [his/her] trust in the sense that it will be employed in the management making decision.”

Interactions decreasing trust

Amongst the interactions that decreased trust in research were aspects reversing the statements mentioned above. S12 (works for Wetlands International) for example mentioned an interaction where the researcher did not acknowledge where the data was from and was reluctant to share them with all involved. S5 (works for Federal Environment Agency, Germany) described an interaction where researchers were "failing to appropriately consider evidence provided by other fields of research". This is in line with the statement by S33 (Environment, Planning and Sustainable Development Directorate (ACT), Australia) explaining a lack of openness to consider comprehensive evidence explaining a situation: "[w]here decisions are aligned [with] personal philosophies (e.g. that certain species should be protected at all costs) [the researchers] were not as strident about ensuring the evidence is robust".

Furthermore, a number of participants described interactions that describe a lack of clarity and proper application of a research code of conduct, where researchers could not explain their research approach (S32, Department of Environment, Land, Water and Planning, Australia), did not disclose their methodologies (S36, Department of Range Resources Management, Lesotho), how they validated their results (S32) or failed to explain and manage uncertainty (S2). Also "vague talking about ecosystem services in general" (S24, works on water management for a Federal Ministry in Germany), "poorly written report" (S3, works for Defra, United Kingdom) and "Error associated with research outputs" (S1, works for the Welsh Government, United Kingdom) led to decreasing trust in research amongst questionnaire participants. The use of scientific language did not impress respondent S8 and S18 (both from Europe) who were not fond of the remaining uncertainty and that "no definitive answer is ever provided". Reversing the description of trust increasing interactions S8 trust decreased due to another interaction, where responses by the researchers he/she interacted were delayed.

However, also new themes emerged within the descriptions of interactions that decreased trust in research. S34 from Australia (who is also involved in research) described an interaction with researchers that was not about cooperation, but a "[c]ompetitive tender process". S13's (works for the Norwegian Government's International Climate and Forest Initiative) trust decreased due to financial and bureaucratic issues. Unfortunately, no further explanation has been provided to be able to put this statement into perspective. S4 (works for the Royal Government of Bhutan) specifically described a situation where there was "[t]oo much focus on the funding opportunity rather than the research in itself", which is backed up by S11, whose trust also decreased if he/she felt lobbied. Whereas S28 (from the province in the Netherlands) disliked that the researchers' conclusion was that “always more research [is] necessary”.

6.3.8 Policy makers’ advice for researchers

The questionnaire participants provided 84 pieces of advice which were allocated to six themes including clearer communication, being connected and match agendas, collaborations and communication throughout the research cycle, awareness of limitations, policy inputs and long-term vision as well as the right communication format and applicability.

Communicate clearly

The majority of advice that policy makers want to give to researchers with whom they are communicating are around the theme of being clear and precise. Whereas some questionnaire participants ask for “simple” messages (e.g. S18), for others “clarity” does not necessary mean “simple”. S21 from the Scottish Natural Heritage puts it this way: “Don't over simplify. If it's complex, explain the complexity” and S24, who works on water management for a Federal Ministry in Germany, continues “... We know that the environmental problems are complex, we need clear statements and no vague speculations.”

Policy makers wish that the research methodology is clear and justified. S18 wants researchers to “clearly show the data used” and S33, who works for Environment, Planning and Sustainable Development Directorate (ACT), Australia, put it this way: “Be very clear about what assumptions, thresholds, level of certainty and other key decisions you are inputting into methods, models and decisions …” and continues that this is important as “… these influence the recommendations [the researchers] make and if it is not clear and defensible then the evidence can be undermined. Not everyone will agree with the assumptions and inputs and that is ok, but not being clear about them can really undermine the outcomes“. This is backed up by respondent S25 (Institute of Environmental Protection – NRI, in Poland) who “like[s] concrete messages, showing the aim, conditions and/or circumstances to make grasping someone else’s ideas easy”. S5 (works for Federal Environment Agency, Germany) suggests that this can be achieved by “uphold[ing] the [research] tradition of giving the parameters: "if you chose this path under these circumstances..." this is important to avoid misleading policy makers”. S3 (works for Defra, United Kingdom) asks to allow for “no room for misinterpretation of results” and S29 (who works for the Greifswald

University, Greifswald Mire Centre and the International Mire Conservation group) that the researchers shall "[d]ifferentiate between facts and interpretation and choices".

Furthermore, policy makers asked for clarity in the conclusions and how uncertainties in evidence is managed (S2, works for the Scottish Government, United Kingdom). S14, who works for the Ministry of Climate and Environment of Norway, asked researchers to conclude with their best possible expert advice based on the given results before stating that more research is needed. S2 also suggested to "… not automatically jump to further research, if needed explain clearly why". In contrast S3 (works for Defra, United Kingdom) wants clear communication about what is needed. Clarity can be achieved if researchers manage to "modify [their] language to the level of knowledge of [their] partner" (S8, works for the General Directorate for Environmental Protection in Poland). Scientific/technical terms shall be either avoided or explained. Altogether 11 quotes referred to this aspect.

Connect and match interests

S37 (works for UN-FAO) generally asked researchers to reach out and contact their audience whereas S30 (works at Ministry of Water in Lesotho) is more specific and suggested the creation of platforms to communicate research. Thus researchers should reach out and connect to policy makers in order to "… ensure that [they] are asking questions that [the policy makers] need answered if [they] want [their] advice to be taken on board." (S33, Environment, Planning and Sustainable Development Directorate (ACT), Australia). If researchers "… understand the needs of the policy maker" (S32, Department of Environment, Land, Water and Planning in Australia) and "… the setting the research should be used in." (S14, works for the Ministry of Climate and Environment in Norway), they could "… look at what specific research is required to address some key policy changes" (S4, works for the Royal Government of Bhutan). This requires some objectivity of the researcher to "… not focus on only what [their] interests are but tweak [their] research for applicability and that can be actually used." (S4). Furthermore, researchers should "ensure [the research information] matches the policy discourse at that time" (S12, works for Wetlands International in the Netherlands). S7, who works for the Biodiversity Conservation Agency at the Ministry of Natural Resources and Environment in Vietnam, asked researchers to provide him/her with "information on wetlands and including peatlands. How to protect peatland? How to wise use of peatland? How to monitoring peatland?"

Collaborate and communicate throughout the research cycle

The theme of collaborative work by researchers spans through various aspects of advice given by policy makers participating in this questionnaire. As the essential ingredient for collaboration transparently (S1, S16, S20, S30, S36) and honest (S21) sharing of findings and results was mentioned. According to S12 (works for Wetlands International) any resulting scientific publications shall be kept accessible. Furthermore, S12 pointed out further valuable roles researchers shall consider at the science-policy interface, arguing that "… scientists are often very much appreciated at senior levels to explain complex topics to non-expert audiences. So, their role goes beyond publishing." Participant S34 from Australia suggested researchers to "use a collaborative rather than competitive approach". Participant S12 stated that "[he/she has] great experiences in collaboration with scientists, and thinks that it strengthens [the policy makers] positions a lot, making [policy makers] more credible too." S35, from Landcare Research, New Zealand, continued that by "communicat[ing] and solving issues together, better uptake" can be achieved. S16 from the Ugandan Wetlands Management Department also asked for "research [to] be participatory".

However there are different ideas about who these collaborations should include. Whereas S12 advised to "work together with NGO's …", S36, works for the Department of Range Resources Management, Lesotho, advised to "work with local researchers" and S34 (works in policy and research in Australia) "to try and include relevant multidisciplinary researchers". Respondent S4 (who works for the Royal Government of Bhutan) likes researchers to "improve communication and coordination among researchers whereby [they] can share and learn from each other and enhance interactions with policy makers with broader perspective". Also research information should be incorporated with indigenous knowledge according to S27 from the Department of Agriculture, Forestry and Fisheries in South Africa. S12 asks all stakeholders working together in "agreeing on how to credit [all data providers]" appropriately, as he/she already mentioned the lack of this while describing an interaction with researchers that decreased his/her trust in research (see above).

Various questionnaire replies addressed the aspect of early engagement and "involvement of stakeholders from the beginning (S27 from the Department of Agriculture, Forestry and Fisheries in South Africa) and that there shall be "… communication early in a project/situation" (S34, policy maker and researcher from Australia). According to S16 from the Ugandan Wetlands Management Department "consultations should be made before designing projects". As mentioned above, if the communication starts early researchers and policy makers can elaborate the research questions together ensuring better research uptake for decision-making (S33, Environment, Planning and Sustainable Development Directorate (ACT), Australia). Moreover communication and exchange shall not only start early, but go as far as “work[ing] together on key conclusions, so that there are no misinterpretations” (S12, who works for Wetlands International).

Awareness of limitations

However, in order for research evidence to be taken into account various policy makers point out the limited time availability of themselves and their colleagues (e.g. S14, S24, S37). They therefore ask researchers to “respond ASAP” (S8, works for the General Directorate for Environmental Protection in Poland) and also to “give [their] best possible expert advice [available], because [he/she] will have to make a decision [at this point in time], and not wait years for more scientific research to be done.” (S14, does national and international work for the Ministry of Climate and Environment of Norway). Nevertheless questionnaire participant S36 (Department of Range Resources Management, Lesotho) advised researchers to “not do a once-off study” but rather to have a long-term vision for engagement, as there are “usually more discoveries yet to be tapped!”

Furthermore, questionnaire participants replied that researchers should understand and be aware “that science is only one input into policy decisions” (S33) and “background for decision-making” (S8). “Values, community expectations, costs, and numerous other socio-economic factors also influence policy” (S33) and “scientific work may not be implemented entirely because of [such] diverse conditions” (S8).

As there are not only time limitations researcher are asked to be realistic and “imagine what an administration can and cannot do.”, said S31, who works at a German Ministry. S24, who works on water management for a Federal Ministry in Germany, specifically asks researchers: “Do not beg for money. If we get the feeling, that a researcher is only interested in funding, it is less interesting. Try to convince with knowledge and project results, than funding will come from alone.”

Communicate in the right format and ensure applicability

Questionnaire respondent S32, from the Department of Environment, Land, Water and Planning in Australia, asked researchers to “make sure the research outcomes are in a form that is useful and that can inform policy and decision making". Current information should be collected (S27 from the Department of Agriculture, Forestry and Fisheries in South Africa) and the key messages distilled (S12, Wetlands International). Given the limited time availability of policy makers as described in the previous paragraph various questionnaire participants' advise the research community to provide them with summaries of current state of knowledge (S37, UN-FAO). Again this should be in "lay man's" language said S28 from the Netherlands. They stressed the importance to try to summarise and validate all recent research literature in an unbiased way (S14, S18, S37). S28 (from the Netherlands) specifically mentions factsheets and S5 (works for Federal Environment Agency, Germany) found "1 page fact sheets or 2-3 page policy briefs" to be "really effective for getting messages to policy level". Respondents S5 and S37 suggested to use visuals to present results to effectively deliver the message and S28 to use animations / info graphics for this. In any case all visuals used, should be self-explanatory (S5).

To increase the applicability further the following suggestions can be taken into account. For S33, Environment, Planning and Sustainable Development Directorate (ACT), Australia, everything from the methods to the recommendations needs to be clearly communicated so it is defensible. He/she is aware that "not everyone will agree with the assumptions and inputs and that is ok, but not being clear about them can really undermine the outcomes". Whilst for S35 (Landcare Research, New Zealand) understanding increased if practical examples were provided. According to S29, who works for the Greifswald University, Greifswald Mire Centre and the International Mire Conservation group, researchers should "be aware of space and time scales" and the local/ country context needs to be understood too, according to S36, who works for the Department of Range Resources Management, Lesotho. Furthermore, research should be kept relevant according to S9, who worked on national and international peatland matters for the government in South Africa, e.g. researchers once provided him/her with guidance on substantive issues that were discussed under the UNFCCC, which led to more trust being formed in this relationship, as mentioned above. Specific added value/benefits for various stakeholder groups, including governments, private sector developers, "for indigenous peoples and local communities depending on peat for their livelihoods" as well as for the ecosystem itself, should be clearly demonstrated (S13, works for the Norwegian Government's International Climate and Forest Initiative).

6.4 Discussion

Various themes run throughout the selected questionnaire question responses, however some are only revealed within responses of single questionnaire questions, whereas others shed more comprehensive light into peatland policy maker perspectives on effective and successful knowledge exchange interactions. The next part of this chapter will elaborate further on these aspects. Furthermore, limitations of the research will be discussed and open question leading to further research conclude the discussion section.

6.4.1 Discussion of research themes derived from this research

Credibility of the research and researcher/research code of conduct

An unexpected result of the study reveals that not all researchers seem to apply research codes of conduct and therefore lose credibility and trust in the eyes of policy makers. For example, according to the questionnaire respondents researchers have proposed impacts that they had no intention of pursuing in their grant applications. Chubb and Reed (2017; 2018) suggested that the pursuit of impact may in some cases compromise research quality or lead to conflicts of interest. According to policymakers responding to the questionnaire, researchers must be clear in their research approach, clearly explain and justify their methods, describe and fully acknowledge the sources of their data and distinguish between the evidence and their own interpretation of their results. Evidence from multi-, trans- and interdisciplinary research should always be backed up with further evidence from the science arena and beyond and include perspectives from other sources such as industry, local and indigenous people (Raymond et al., 2010). Research aiming to improve science-policy communication and overcome the implementation gaps seldom reflects on this issues. According to Tinch et al. (2018) and Bennett et al. (2018) research needs to be “robust”, “rigorous” and “defensible”. The latter depends on the objective, whether or not it needs to be defended against something else or if it really addresses the participants call for clarity of the communication. Scientific literature and participants view leave no doubt that well-evidenced research is sought after.

Greater awareness of policy makers’ agenda, needs and limitations

Whereas research, including the previous two chapters of this thesis, mainly focuses on science-policy interfaces, the results of the questionnaire made clear that this focus is only a fraction of the bigger picture of the necessary stakeholders needed in order to achieve sustainable environmental governance. In fact policy makers use science as only one source of knowledge to base their decisions on. However this very aspect that science is and cannot be the only sources for decision-making, should be reflected more openly in the research community and greater awareness is needed in this regard (Reed and Meagher, 2019). Results from the questionnaire show that, even though science is mentioned as the main source of knowledge and 97% of all surveyed policy makers draw upon researchers for their decision-making, further sources that were mentioned included policy makers (63%) and colleagues in their institution (69%), public (28%), media (28%), friends (9%) and local people and research users, reports from ministries and environmental conventions, civil engineers, industry, non-governmental organisations and further public bodies. When policy makers were asked to give advice for researchers, only two of them specifically call for awareness and understanding that science can only be one of multiple knowledge sources inputting into their policy decisions.

Lingard (2013) argues that research affects policy in multiple ways and in varying timeframes. Several policy makers point out that they wish that researchers align their research and therefore their research cycle with their own needs and therefore the policy cycle. Greater awareness is needed into how research findings can and do feed into informing policies (Bennett et al., 2018). Decision makers participating in this research ask for alignment of research questions at the outset of the research project. According to Andrews (2012) research cycles that match up with policy agendas include a scoping phase, where all stakeholders need to be involved and their needs analysed and prioritised. Transparency is important throughout the planning and implementation phase and knowledge outreach strategies need regular evaluation and possible adaptions (Andrews, 2012). Timing of the communication of results and preliminary results need to be clear and/or clarified. A questionnaire respondent from this research encourages researchers to provide their best expert advice timely as policy makers have to make decisions based on the current status of research at any given time. Researchers should produce “time-critical research” fast enough to be able to affect political outcomes —even if this means that the speed exceeds current research cycles (Laurance et al., 2012). This is particularly pertinent in times of environmental crisis. Further literature by Lingard (2013) backs up results from this study, advising researchers “to not do a one-off study” (S36, a policy maker who works for the Department of Range Resources Management, Lesotho) but rather to have a long-term vision for engagement as academic research usually has effects and impact in the longer term. This includes changing values and views of stakeholders involved (Lacey et al., 2018; Mascia et al., 2018). However research funding often pressures for shorter-term impact (Lingard, 2013).

Beyond the time limitations, policy makers state that they are not equipped with endless financial resources and ask researchers to “not beg for money” and to be realistic with their expectations. The focus for the interaction with the policy maker shall not be on funding but the content and results of the research, otherwise policy makers seem to lose interest.

Furthermore, amongst the questionnaire participants there are several opinions about complexity and various different complexities are mentioned. Whereas most acknowledge complexity overall, some call for simplicity. They particular call for simplicity in the communication and presentation of results. Others were more specific and pointed out complexity of the environmental problems, and simply asked researchers to explain this and make their research approach to address these problems and all results as clear and comprehensive as possible. However questionnaire results do not touch on the complexity of potential conflicts of interests due to involvement of multiple actors at multiple levels (Hodgson et al., 2019). Participants asked for stakeholder engagement, but did not mention how diverse and often conflicting values and world views influence the decision-making process.

Addressing needs

Addressing needs is coupled with meeting expectations in the first place. Policy makers require specific timely answers in order to make evidence-based/evidenced-informed decisions. However, the typical policy decision-making processes are quite complex, involving evidence analysts, policy analysts, public consultation and consultation with experts from different sectors (Head, 2008; Howlett, 2009) and in some cases lobbyists (Joos, 2016). So the timing of the environmental arguments need to be known and met (Tinch et al., 2018). Once the current relevant knowledge needs (Lövbrand, 2011) are addressed the main issue in order to be able to improve knowledge uptake seems to be the lack of clarity. In line with questionnaire responses Tseng (2012) says that interpretations of evidence is key, but “research does not speak for itself”. If research projects and their results are tailored (e.g. Laurance et al., 2012) and arguments bundled and framed it increases the effectiveness to reach the audience (Tinch et al., 2018). Furthermore, clarity and transparency could reduce the risk of misinterpretation of research, avoiding conflicts amongst participating stakeholders (Hodgson et al., 2019).

This research suggests that well-evidenced research should be communicated in the right format. S32 [Department of Environment, Land, Water and Planning, Australia] for example did his/her own research on peatlands before working on wetland policies and hence is aware of the miscommunication that non-target specific communication can lead to. In fact S32 valued that he/she could make a decision based as the research work that has been provided by the researchers h/she interacted with, was tailored specifically to their needs and the outputs were ready to be uses. Useful formats of knowledge and data mentioned by the questionnaire participants included for example summaries and reviews of existing scientific literature. Bennett et al. (2018) promote two synergistic approaches they suggest can help science to inform decision-making: systematic review and evidence banking, which includes publishing of raw data. Systematic reviews are increasingly valued as they ensure research findings are robust and generalisable for policy (Reed et al., 2020). Whereas the provision of quantitative data has been mentioned twice amongst participants in the questionnaires, the publishing of raw data specifically is a suggestion that has not been highlighted by any of the questionnaire respondents. However publishing of raw data is believed to be useful to increase effectiveness within the research community (Fecher et al., 2015; Wicherts and Bakker, 2012).

In order for research findings to be received by policy makers their accessibility via open access is not sufficient. Only two of the participating policy makers mention sourcing their knowledge required for decision-making through research literature. This finding is backed up by Laurance et al. (2012) who found that research papers were among the least used sources of information by Scottish Government policy-makers working on peatlands. Whereas publishing scientific papers is important for many reasons and does reach various audiences – mainly specific research communities, findings of this research confirmed that it is an insufficient format to reach policy makers. Analysing questionnaire responses it became apparent that human connections and more direct personal forms of knowledge exchange are key. If policy makers need specific information they often turn to trusted peers (Carolan, 2006; Tseng, 2012) and engage with trusted researchers and intermediaries (Cvitanovic et al., 2015; Reed et al., 2018; Weichselgartner and Kasperson, 2010) or boundary organisations (Cvitanovic et al., 2015; Wreford et al., in press).

One-way communication versus two-way dialogue

Amongst participants' descriptions of useful and advisable modes of communication were workshops, conferences, stakeholder meetings, telephone calls and emails. These include assembling both one-way as well as two-way communication and dialogue. In contrast to this, the literature tends to emphasise the need for dialogue and criticises the linear "knowledge transfer" or communicative model (Nutley et al., 2007; Van Kerkhoff and Lebel, 2006; see chapter 4 and 5). However, it is consistent with emerging theory that suggests engagement between researchers and policy-makers (or any other public or stakeholder) is equally valid in one and two-way modes, with the appropriate mode selected to match the purpose and context of the engagement (Reed et al., 2018). Consistent with this, a number policy makers participating in this research simply wanted to be kept in the loop via one-way communication. Others showed more signs of willingness to go into dialogue and even co-production of knowledge (see more on this in the next section). Many publications call for "proactive" and "constructive" dialogue (Laurance et al., 2012; Tinch et al., 2018) and "multi-party" dialogue (Bielak, 2008). Dialogue between research and policy typically addresses user needs and frame problems amongst others, and may therefore improve the likelihood of research outputs that are relevant for the policy issue at stake and readily applicable (Young et al., 2014). To receive even one-way communicated knowledge and needed information policy makers often turn to trusted peers and intermediaries (Carolan, 2006; Tseng, 2012) besides researchers, therefore it is important to consider the involvement of further stakeholders and required relationships in that process.

Multi-disciplinary and multi-stakeholder approach: collaborations and knowledge co-production

Some research promotes multi-, trans- and interdisciplinary exchange and collaboration (Fazey et al., 2014; Marshall et al., 2017; Nesshöver et al., 2017; Young et al., 2014). Thus some communication might take place solely between researchers and policy makers. However, most research publications and also questionnaire respondents call for multi-stakeholder approaches exceeding involvement of research and policy communities. Asked for advice S34 asked for multi-disciplinary. This is in line with multiple publications which call for multi-disciplinary approaches connecting research with other sectors beyond policy including economics, sociology, private sector, indigenous community (Laurance et al., 2012), media, public (Likens, 2010) amongst others. The ability to communicate research beyond academic circles enables to foresee chances of research uptake and implementation in environmental policy contexts compared to research that is designed to have little or unclear practical impact from the outset (Milner-Gulland et al., 2011).

To this point it is unusual for research questions to be framed jointly with potential users of that research. However some policy makers participating in this research demonstrate a willingness to even co-produce knowledge altogether. These calls are also echoed in the current literature on evidenced-based and evidence-informed policy-making (Cairney, 2016; Dicks et al., 2014; Likens, 2010). Some lessons learnt can also be drawn from science-policy initiatives, such as the former European Platform for Biodiversity Research Strategy (EPBRS) (Young et al., 2014), which initiated the Network of Knowledge (Nesshöver et al., 2016) and is now exceeded by the EKLIPSE project (Raymond et al., 2017). There are also a number of national biodiversity themed science-policy interfaces, such as the German (NeFo project[39]) or Belgian biodiversity platform[40]. Further international platforms and mechanism such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) or the Convention on Biological Diversity's national biodiversity strategies and action plans (NBSAPs) are major ways for implementing biodiversity scientific (as well as indigenous) knowledge into international, regional and national policies (Koetz et al., 2011; Sarkki et al., 2016). However the evaluation and reflection of effectiveness of such platform seems to leave room for improvement (Esguerra et al., 2017; Koetz et al., 2011; Tengö et al., 2017, Young et al., 2014).

One critical issue is addressed by Sarkki et al. (2016) who states that although the environmental governance sectors might have been reached, further action in other policy sectors is lacking or insufficient and this 'responsibility gap' needs to be closed in order to achieve effective environmental protection.

Despite currently increasing emphasis on the use of knowledge intermediaries or knowledge brokers (Meyer, 2010) to initiate and facilitate collaborations at the science-policy interface (Bielak et al., 2008; Sarkki et al., 2013) no participating policy maker mentions them specifically. This of course can be due to the nature of the questionnaire questions that asked about advice, useful, least useful, trust increasing and decreasing interactions specifically with and for researchers. However in order to call upon and apply professional support by intermediaries, policy makers need to be aware about their effectiveness in the implementation gap of research evidence. Therefore, besides the call for more research on mechanisms to support researchers to produce usable evidence and engage policymakers and intermediaries (Tseng, 2012), existing knowledge need to be received successfully by the policy community (see chapter 4 and 5).

Trust development

Tseng (2012) states that relationships are vital to receive knowledge and stakeholders turn to trusted colleagues, however there are still unknowns as to how this trust is formed and develops over time. Results of this study suggest that in order to develop trust, expectations and needs

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[39] www.biodiversity.de accessed 2 February 2018.
[40] www.bioidversity.be accessed 2 February 2018.

have to be met. Building trust can take time and take various, personal and transpersonal routes. If researchers did not implement the research code of conduct and did not clearly communicate their research, it hindered questionnaire respondents to form trust. Furthermore, personal interactions between policy makers and researchers including informal exchange help to increase trust (Bouty, 2000). More on trust development can be found in chapter 5 and about the required network structures in chapter 4 of this thesis.

6.4.2 Methodological limitations

The qualitative analysis of this chapter is based on 32 completed questionnaire response sets. As the questionnaire was aimed at international peatland policy makers, of whom less than 1% knew me personally, a low response rate of 5% is of no surprise. All peatland policy makers that I do know responded and transitivity trust may have played a role in incentivising others to reply. Low-response rate is reflected in the call of participating policy makers to increase awareness of their limited time availability. Based on the busy work schedule of the target group, it is a success that 37 policy makers took an average of 10 minutes to fill out the questionnaire. This however, led to very brief answers that were often very difficult to put into the required context or not at all.

Even with this limited responses the emerging themes are able to triangulate and enrich the data and results from previous chapters. Most questionnaire responses are reflected as part of active discussions amongst researcher studying communication at the science-policy interface. The real additional values of this study lies in the approach to shed light into the policy maker perspectives of knowledge exchange and analysing further trust-forming and demolition aspects of communication between these two actor groups. By asking for aspects that led to decreasing trust and least useful aspects of communication with researchers, policy makers were able to provide a more comprehensive picture of what in turn makes out successful exchange.

The questionnaire had a wide international coverage and armed to capture peatland policy maker perspectives. Even though the questionnaire was aimed at peatland policy makers, the majority of the results are discussed in existing literature of other policy fields too, including the wider environmental governance literature as well as health policy. Peatland governance was chosen as focus as it builds a narrative for this thesis, but the more important reason is that peatland protection plays an important part in environmental governance and affects various actors on various scales.

Given the limited questionnaire responses an extension of the questionnaire to capture further international peatland policy maker perspectives as well as to other policy fields could strengthen results or point out differences. Follow-up in-depth qualitative interviews can further enrich evidence of policy makers' perspectives on good knowledge exchange.

6.5 Conclusion

First of all it is reassuring to record from the data that knowledge exchanging interactions between policy makers and researchers do take place. From the questionnaire responses about useful and least useful, as well as trust increasing and decreasing interactions, from international peatland policy makers and consultation of current environmental governance literature, the following can be concluded. A number of key factors have been identified to enable all involved stakeholders to achieve successful knowledge exchange, increase the likelihood for research uptake for decision-making and the development of trust between the involved actors:

- Research that is credible and applies codes of conduct to ensure quality.
- Clear communication of expectations and needs and evaluation of these throughout policy and research cycles for better alignment.
- Communication in usable formats and applicable for the end use purpose.
- A minority of policy makers asked for timely delivery of research results at the end of the research project (one-way transfer).
- A majority of policy makers asked to be involved in the research process from early on (e.g. the research question forming phase) and be involved throughout in a co-production as collaborators.
- Regular two-way dialogue allowing for better understanding of needs and limitations of all involved stakeholders.
- Involvement of multi-disciplinary/multi-sector stakeholders to collectively find solutions to halt biodiversity loss and combat climate change.
- Regular meetings of all relevant stakeholders, exchanging openly, listening to each other needs, wishes as well as limitations, align these, finding common ground and maintaining their relationship so that trust can develop over time, increasing the likelihood for knowledge uptake for decision-making.
- Use of neutral/unbiased and professional intermediaries to moderate, mediate and facilitate the alignment of policy and research cycle from the outset of research projects

and throughout the entire research process, as well as the different values and belief systems of all involved stakeholders.

Successful environmental governance requires intense collective actions involving multiple stakeholders over time. To improve this this research points to the need for collective action with a strong relational approach. This is essential in order to close the 'responsibility gap' and build a key ingredient for building effective environmental policies. Continuous effort addressing these recommendation will hopefully accelerate the search and implementation of solutions to the most pressing environmental issues of our time.

Chapter 7 - Conclusion

7.1 Introduction

It is clear that the pressing environmental problems of our time can only be achieved if good and sound knowledge has been produced and is taken up by relevant stakeholders for decision-making. Social interactions and intensive multi-stakeholder engagement processes play an important part in this. Therefore, the overall aims of my PhD were to advance theoretical, and empirical knowledge about the exchange and implementation of knowledge in environmental especially peatland decision-making. In order to achieve these primary aims, this thesis addressed the following objectives:

1. Analyse the relative importance of key factors enabling knowledge uptake and evidence-informed decision-making by exploring two peatland case studies.
2. Explore the knowledge exchange network and decision-making structure in two peatland ecosystem case studies to identify and explain which structural elements facilitate the uptake and implementation of ecosystem service knowledge in peatland governance.
3. Analyse policy makers' perceptions of successful knowledge exchange at the peatland science-policy interface.
4. Formulate recommendations for stakeholders at the science-policy interface to exchange their knowledge successfully with the other relevant stakeholder groups, increasing the likelihood that their knowledge informs and is implemented in decision-making.

To address objective 1, the current literature about uptake of environmental knowledge for decision-making is summarised in chapter 2 to set the scene for this research. Chapter 3 described the mixed methods chosen for the in-depth analysis of the two case study projects. A combination of literature review, stakeholder interviews, stakeholder workshop discussion, Social and Bayesian network analysis and a questionnaire aimed at international peatland policy makers were applied. Chapter 4 presented findings from in-depth social network analysis of the case studies. It explored and discussed the knowledge exchange network and decision-making structure, as well as the underlying theories/reasons behind them that mattered for the uptake and implementation of peatland ecosystem service knowledge for decision-making. The next chapter is based on a Bayesian network analysis model of each case study analysed the relative importance of the identified key factors enabling knowledge uptake and evidence-informed decision-making to serve conservation. The final results chapter 6 shed light on the policy makers' perspective of successful knowledge uptake, addressing objective 3. Objective 4 is addressed in this concluding chapter.

7.2 Key contributions

Key empirical contributions from this research include:

- Chapter 5 analysed and discussed the relative importance of key factors that improved the probability of decision-making and knowledge uptake in the two peatland case studies. Actors who made decisions based on their communication with each other tended to have known each other for longer, and knowledge was frequently transferred, received and exchanged via dialogue between them. Empirical evidence for both the MoorFutures and Peatland Code case studies showed that the probability for decision making increased with increasing frequency of communication amongst network actors. Probabilities increased even when communication occurred at least once a year compared to the baseline scenario, the "as is" - state of the modelled data, of the Bayesian network model. The optimal decision probability occurred during weekly communication. The more frequently network actors communicated in person, via phone and/or by email, the higher the probability that decisions were made, based on those communication relationships. All three modes of communication (personal face-to-face, phone and email) were important and the use of either of them increased the probability for decision-making.
- Additional qualitative data from the stakeholder interviews revealed that decisions amongst case study actors were made not only based on dyadic interactions, but also based on multiple encounters over time and in group decision-making settings. Trust could also be identified as an ingredient for trust as well as a result of trust through this additional material.
- Qualitative data from the international peatland policy maker survey revealed calls for the use of neutral/unbiased and professional intermediaries to moderate, mediate and facilitate the alignment of policy and research cycle from the outset of research projects and throughout the entire research process, as well as the different values and belief systems of all involved stakeholders.
- The research was able to respond to a call to look closer into how trust is developed and maintained (Boschetti et al., 2016; De Vries et al., 2014) over time in a relationship

between stakeholders. Therefore, in addition to the original objectives of this thesis, it became clear that trust plays an essential role for successful knowledge uptake. Roles of trust development over time could be studied based on proxies. These suggest, that contrary to the suggestions of Lacey et al. (2018), that trust might have a critical phase in years 1-5. Data suggests that trust might not grow steadily in the early phases of a relationship nor that a plateau over a period of up to 27 years exists, as suggested by Lacey et al. (2018). It can be concluded that the development of a network and trust within relationships takes time and is closely connected to higher probabilities of knowledge exchange, uptake and hence decision-making.

Theoretical contributions from this research:

- The research showed that there were mismatches between perceived and reported communication between many network actors in the case studies, where exchanges reported by one actor were not recognised or reported by the actor who they apparently communicated with. This highlights the need to focus on successful transmission of information to the target stakeholders (rather than simply successful dissemination of information). The research revealed three critical features that can support this transmission: (i) Dialogue led to more decisions being made by the stakeholders and ensured a higher likelihood that the transferred messages were received and taken into account by the target person. (ii) Decentralised governance structures seem to facilitate better solutions to environmental issues long-term. Additional information about the projects suggest that both case studies, which use adaptive management strategies, might be in a transition from more centralised towards more decentralised network structures, although the MoorFutures project seemed to be progressed further in this direction than the Peatland Code case study network. Findings suggest that at the beginning of network development, central actors can make deliberate stakeholder selection choices, developing and maintaining weak and strong ties as well as homophilic and heterophilic connections with network actors over time. (iii) The social network analysis results suggest that a successful and stable network consists of a combination of legitimate and credible individuals who cover different roles and tasks. These include more centrally positioned actors responsible for facilitating, listening and creating the framework to create stable trusting relationships for effective knowledge exchange, actors who are responsible for bundling, transferring and diffusing knowledge within and beyond the network, and actors located at the periphery whose expertise, views and ideas are included through regular meetings.

- While it is generally known that increased frequency of communication leads to more knowledge exchange and increases the likelihood that exchanged knowledge contributes towards decisions, this research has provided empirical evidence that communicating more frequently than once a year was necessary to significantly shape decisions within the two case study networks. While it is not possible to generalise widely from this finding, it suggests that a minimum frequency of once per year (evidenced suggests that quarterly exchange increased decision-making probability even further) may be necessary for researchers to maintain their network relationships and be able to contribute adaptively to dynamic policy-making processes. These findings may have important implications for the resourcing of policy communication within the research community, and highlight the additional value of professional knowledge brokers within research teams or boundary organisations within universities to fulfil this role effectively. Consequently, the awareness amongst researchers for regular exchange of knowledge shall be increased.
- There have been few empirical surveys of knowledge exchange processes in science-policy networks from the perspective of policy-makers, and this research has provided a number of useful insights into the perceptions of this important group that could shed light on how knowledge could be more successfully exchanged in future. The first of these insights shows the importance of investing significantly more than is current practice (in research projects, Government consultancy contracts or more informal science-policy engagement) in ongoing two-way dialogue about needs, expectations and limitations throughout the research and policy cycle for better alignment. Although there has been some attention to the timing of engagement between actors in science-policy networks in the literature, this research has provided insights into the intensity and regularity of engagement needed to inform evidence-based policy decisions. This is an important consideration for the future funding and design of policy-relevant research, which needs to provide resources and time for the co-production of research proposals, and mechanisms that can enable research to adapt rapidly to changing policy contexts, so they remain relevant to the decisions being made. This links to a further theoretical contribution from the survey of policy-makers, which showed that while a small number still valued one-way communication of results at the end of a research project, the majority wanted to be involved in the research process from early on, including the scoping of research questions and methods, and to be involved throughout the knowledge

co-production process as collaborators. This too calls for a new approach to the funding of policy-relevant research that enables research to remain independent, in line for example with the British Haldane Principle, and yet enables much greater involvement in the research process than is normally seen by the research community. Policy respondents were able to clearly distinguish between their involvement in shaping research questions and methods, and helping adapt research to changing policy contexts, versus interfering with the interpretation of results and helping shape recommendations. This is an important nuance that enables members of the policy community to engage more actively than some researchers or research funders may currently allow for.

The novel mixed-method approach chosen for this research has provided valuable in-depth evidence advancing the pool of case studies knowledge pertaining to the two case study contexts and consider wider policy maker perspectives to provide more generalisable lessons for the design of science-policy networks and to enhance the likelihood that researchers interact with members of the policy community in ways that lead to the uptake of knowledge. Based on this evidence, practical recommendations have been made for research and policy.

7.3 Personal reflections on the learning process during the PhD research

Prior to my PhD I never thoughtfully reflected on the existence of different epistemological perspectives. It was enlightening to do so and being able to place my own viewpoint in the category of a critical realist. The mixed-methods and case studies approach for this research seem like a natural fits and allowed for an in-depth analysis of complex social network systems and triangulation of data using the combined strengths of the chosen methods. Although not intended to be representative or provide universal findings, the two case studies were able to generate some generalisation to similar environmental contexts. There are also able to provide concrete benefits and food for reflections to the research participants in their specific work settings (Schofield, 1993; Yin, 2013).

At the beginning of my PhD I wanted to find out how to best integrate “scientific” knowledge into “political” decision-making, however over the course of my PhD I removed two words: “scientific” and “political”. Having said this - I still love to enable scientific knowledge to be integrated into environmental policy – very much so. My big motivation is to find and implement the most efficient ways to solve the environmental problems of our time. Therefore, it became clear that

this requires more stakeholder groups to be involved – not just researchers and policy makers. Growing emphasis on the inclusion of indigenous and local knowledge into global assessments of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Thaman et al., 2013) together with the conversations with multiple people from diverse backgrounds over the past years, and results from this study (especially from chapter 6 – policy makers' perspective on successful knowledge exchange and chapter 4 – social network analysis) allowed me to realise that a combination of homophilic and well-facilitated collaborations with heterophilic stakeholders are essential ingredients to find and implement solutions for environmental issues. I believe that respectful encounters amongst diverse stakeholder greatly improves the understanding for each other and are requisites towards world peace. The inclusion of various sources of knowledge from all relevant stakeholders is essential.
The second word that I removed from my initial PhD title is "political", as it became apparent that multiple decisions are made within the decision-making progress. Every stakeholder makes countless decisions every day, and the sum of all of these results in the progress (or also the stagnation) towards solving these problems. Most decisions are made based on our unconsciousness based on values, beliefs, norms. Decisions are not solely made by policy makers but should/could be the result of collaborative engagement of multiple stakeholder groups and multiple collective decisions. Future directions should therefore ensure that evidence is not presented as "scientific truth" (e.g. Pielke 2007; Svardstad et al., 2008) as this could alienate and demotivate other stakeholder groups to actively engage and add their knowledge towards multi-sourced, less lobby-biased decision-making (Kaika and Page, 2003).

I would also like to note that over the duration of my PhD research, I changed the wording "(scientific) evidence-based" to "evidence-informed" decision-making. This is due to another important ingredient – respectful knowledge exchange interactions. No single stakeholder group has a complete set of evidence and knows it all, however if for example researchers regard their knowledge as the only source of knowledge for decision-making without considering others and "tell" policy makers what they should do, "based" on their research alone, policy makers might not consider this research for their decisions with open arms. They are unlikely to be happy to be told what to do. This can be regardless of the actual value and credibility of the research results. This may not be, or perceived as, a respectful encounter between equals at eye-level and therefore might unfortunately jeopardise the goal of knowledge uptake and ultimately making the best sustainable long-term policy decisions including multiple stakeholders' perspectives.

7.4 Areas for future research

Knowledge brokerage and the evolution of trust

The actual value of involvement of knowledge brokers and clear measurements of the uptake of ecosystem service knowledge that can be achieved with the engagement of knowledge brokers is still limited and existing knowledge on this needs to be further distributed (Cvitanovic et al., 2017). As there were no specific knowledge brokers in the case study networks from the outset, it can therefore only be speculated if the quality of exchange and trust building could have been improved if they would have been involved from the start of the each case study project. Open questions remain how to evaluate the impact that knowledge brokers might have towards increased decision-making and how they are/were able to support the knowledge uptake and relationship building. Further research is also needed into how stakeholder engagement starting from different phases in a project affects the amount of knowledge uptake and impact that can be achieved. For example, if expectations of stakeholders cannot be aligned early on (Lacey et al., 2018), understanding for each other developed and common vision and goals created (Bielak et al., 2008) can this be done/compensated/reversed through engagement of knowledge broker at a later stage in the project? Or is there indeed a chance at all for a successful inclusion of a knowledge broker at a later stage in the project? The open question regarding the best timing to merge the different time tables of the multiple participating stakeholders still remains. Furthermore, can trust building be measured and therefore taken into account in evaluations? Some projects (such as the TEEB study[41]) already transparently acknowledge the potential negative consequences of broken trust and name it as one of the project's objectives to ensure that trust should be maintained throughout. Having studied trust building in closed case study networks, which mainly consisted both of direct but also indirect connections, it remains unknown and requires further knowledge as to how trust being built and maintained over long distances, where stakeholder might never meet each other in person? As trust building and decision-making is connected to the unconsciousness and is therefore in part based on values, beliefs, norms (Gorddard et al., 2016; López and Cuervo-Arango, 2008), further research should include further multi-disciplinary collected evidence, e.g. from psychology, neurology and broader interdisciplinary fields such as transformation research.

[41] http://www.teebweb.org/ accessed on 24 April 2019.

Evaluating knowledge exchange to understand knowledge uptake and impact

Given the difficulties with measuring and evaluating successful knowledge exchange, it is important to synthesise and publish more lessons learnt, good practice (Oliver and Cairney, 2019) and encountered failures from implementing knowledge exchange strategies and impact evaluations (Akhavan and Pezeshkan, 2014; Liebowitz, 2006). There are a number of ways in which knowledge exchange could be more effectively evaluated and deeply understood. Here I particularly propose to study how the precise time for engagement can be aligned, merging the timetables and considering the daily habits of involved and targeted stakeholders to ensure effective knowledge exchange and hence uptake for decision-making. This requires a deeper understanding of the involved stakeholders and the ability to take their perspectives on board.

Results of this PhD research indicate that the probability of decision-making increases with increasing perceived usefulness of the communication. Future evaluation research and practice could look into the potential to use the analysis of stakeholder replies regarding the "usefulness" of the communication connection in surveys to make predictions of decision-making probability during evaluations of knowledge exchange. Hereby the potential of the descriptions of relationships as "very useful"/"useful" might be used as a proxy that correlates with the decision-making probability for the research evaluation and impact studies could be explored.

Finally, knowledge exchange is widely regarded as an important precursor to research impact (Fazey et al., 2013; Reed et al., 2014), but little is known about the extent to which knowledge exchange processes lead to impact, or which types of knowledge exchange are more likely to lead to impact in different context. Future research could usefully consider what happens after successful uptake of research by members of the policy and practice community, considering the factors that influence whether or not knowledge that is taken up actually informs or shapes policy and practice.

Developing and evaluating general principles for knowledge uptake

Results of this study are derived from two closed case study projects with clearer network boundaries and potentially clearer common aims, goals and vision. As a result, it remains unclear if these results can be duplicated to situations with a less clear project boundary. Furthermore, in-depth case study research including social and Bayesian network analysis is very time consuming. However, if multiple in-depth case studies allowing for cross-sectoral comparison (other research field/topics) are conducted, correlations and causalities and more general principles for successful knowledge uptake could be derived. There in a first step there is a need to standardise data that is collected in peatland social science, so that it is synthesisable. This can then be followed by actually synthesise via systematic reviews and meta-analysis. Current research is under way to develop core outcome measures for peatland science. This still needs to be done for peatland social science. And yet in the meantime the existing knowledge about effective knowledge exchange has yet to be taken up by a critical mass allowing for wider diffusion resulting in successful wide-spread implementation of knowledge in environmental governance.

7.5 Target group specific recommendations

The forth objective of this thesis was to formulate recommendations for stakeholders at the science-policy interface to exchange their knowledge successfully with the other relevant stakeholder groups, increasing the likelihood that their knowledge informs and is implemented in decision-making. The following recommendations are derived from the reviewed literature and the results of this PhD research and address target specific multiple relevant stakeholder groups.

Funders

- *Allocate* long term sustainable *funding and legitimising* of science-policy interfacing organisations/initiatives and knowledge brokers activities to be part of every research project from the outset – even before the start to get relevant actors on one table to formulate the problem that needs to be addressed and a common phrasing of the research question together, plus a discussion of the time frame for a realistic delivery of project milestones and results.
- *Call* for intense collective actions involving multiple stakeholders over time using a strong relational approach.

Scientific institutions

- *Legitimise and support* the above.
- *Considering* development of a research implementation strategy.
- *Recognition* of the network management task and *legitimising* trained and therefore skilled people/knowledge broker to implement this enabling the formation of long-lasting sustainable trusting relationships that enable the optimal knowledge uptake for decision-making e.g. through deliberate network management.
- *Encourage and reward* network activities that increase knowledge uptake and hence research impact beyond academia.

Knowledge brokers

- *Recognising* that the ideal frequency of communication might be by at least quarterly communication over the entire time of the relationship (including relationships lasting >20 years) using all modes of communication.

- *Organising* regular meetings (minimum once a year and individual exchange at least quarterly) *creating* opportunities for the entire network to ensure everyone knows each other and their skills and expertise and therefore creating essential network connections that enables stability over time.
- *Designing and facilitating* these meetings to enable dialogue.
- *Ensuring* that knowledge is received by the target group, ideally through personal communication. Where both the one- as well as two-way knowledge exchange should be *tailoring* transferred messages to the target audiences' needs using the appropriate mode of communication.
- *Awareness* of the critical time for trust-building in the years 1-5, where trustworthiness needs to be proven.
- *Developing* homo- and heterophilic network contacts covering multiple disciplines.
- *Expending and practicing* their skill-set, including active listening.

Bridging organisations

- *Providing* "neutral" space and appropriate atmosphere for dialogue and hence the development of understanding and building of trust.
- *Remain* independent.

Policy makers

- *Be open* to learn from other stakeholders.
- *Be prepared* to "learn another language" and ways to transport their needs for specific evidence enabling them to fill knowledge gaps for current policy development.
- *Be specifically proactive* to include biodiversity/ecosystem service related issues and knowledge into meetings with policy makers from other policy sectors beyond the environmental sector, e.g. transport, finances, health, …

Scientists

- *Be open* to learn from other stakeholders.
- *Be prepared* to "learn another language" and ways to transport your research results beyond the mere publishing in isi-listed journals.
- *Engage* in stakeholder dialogue and thereby further clarify if the transferred knowledge is indeed received by the target person.
- *Avoid* using the wording "evidence-based" and use "evidence-informed" knowledge instead.
- *(Co-)Produce* target group specific outreach together with multiple-stakeholders and the end-users of the research, e.g. by using different media such as Twitter and preparing press releases.
- *Collaborate* with professional science communicators and knowledge brokers.

Table 7. 1 Recommendations for specific target groups (funders, scientific institutions, knowledge brokers, policy makers and scientists)

7.6 Conclusion

The research has made clear that effective communication at the interface between biodiversity especially peatland research, policy and practice is important to ensure that evidence is taken into account for environmental policy-making. The research had limitations of which decision-making related factors could be included or studied in depth, most of which could be covered by the chosen mixed-method approach combining qualitative and quantitative data analysis. However, even with this methodological mix power dynamics remain difficult to study and interpretation of trust derived via proxies might be read with some caution. Amongst the key studied factors that did enrich empirical evidence base, and that improved the probability for decision-making and knowledge uptake was the factor of the frequency of knowledge exchange with relevant stakeholders. During multiple interactions knowledge can not only be transferred and received, but actively exchanged via a two-way dialogue. This in turn can help to close the observed mismatch between transferred knowledge and actually the perceived reception of this knowledge. Regular engagement can enable the development of functional trusting relationships as well as to successful co-production of knowledge by multiple stakeholders. Even though trans-/inter-/multi-disciplinary stakeholder engagement approaches might be difficult, they are essential to tackle the pressing environmental issues of our time. If they are successfully applied, they can result in a wider positive environmental impact. Deliberate and empowering network and stakeholder management and professional skilful facilitation can contribute to the creation of collaborative success. Decentralised governance structures were found to facilitate better solutions to environmental issues long-term and should allow for a combination of homophilic and heterophilic stakeholder perspectives to be included in the active stakeholder engagement process. This study provides a basis for improving communication and knowledge adoption and implementation strategies in the field of ecosystem service conservation and beyond. Continuous effort addressing the above listed recommendations will hopefully enable or even trigger an acceleration of the search and implementation of solutions to the most pressing environmental issues of our time.

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Appendix

Appendix A. Table 1. Showing the data resulting from the Machine learnt Bayesian network analysis (MLBN) for the baseline scenario, scenario 1 and scenarios 2a and 2b. The first column shows the factors that were analysed, which were represented by the nodes in the MLBN and column two represent their different states. Row one to three describe the theme of the chosen scenarios. Row four distinguishes between the two case studies: MoorFutures (MF) and Peatland Code (PC). Numbers represent the probabilities of the different status of the nodes in %. If one node was set as a target, the specific status is highlighted with 100% probability in bold.

	theme			optimal		length of relationship (in years)																			
		baseline scenario		scenario 1		scenario 2a										scenario 2b									
	scenarios	baseline		100% decision		<=1	>1-5	>5-10	>10<20	>=20	<=1	>1-5	>5-10	>10<20	>=20	<=1	>1-5	>5-10	>10<20	>=20	<=1	>1-5	>5-10	>10<20	>=20
	case study	MF	PC	MF	PC	MF					PC					MF					PC				
length of relationship (in years)	0	25	35	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<=1	7	7	8	9	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0
	>1-5	29	27	33	33	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0
	>5-10	19	16	26	26	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0
	>10<20	12	10	19	18	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0
	>=20	7	6	11	10	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**	0	0	0	0	**100**
frequency of communication	weekly	10	5	17	12	8	11	14	16	17	5	6	8	10	11	11	16	18	19	21	7	11	13	14	15
	monthly	18	10	30	22	20	21	25	27	27	13	13	16	18	19	27	30	31	31	32	18	22	23	24	25
	quarterly	19	17	29	32	27	23	26	27	27	27	22	27	29	29	29	29	29	30	29	30	33	33	34	34
	twice a year	11	10	13	15	20	13	14	13	13	21	13	15	14	14	18	13	13	12	11	20	16	15	14	14
	once a year	8	10	7	12	15	9	9	8	8	21	12	14	13	13	12	8	7	6	6	18	12	12	11	10
	no communication	34	49	4	7	9	22	12	9	8	14	34	20	15	14	3	3	2	2	2	6	6	4	4	3
usefulness	very useful	31	22	58	53	20	34	45	55	57	17	27	37	48	48	32	55	62	69	73	27	51	57	65	68
	useful	24	19	33	36	44	29	32	29	24	43	25	31	29	25	54	37	32	28	22	56	38	36	30	25
	slightly useful	8	8	4	5	24	11	9	6	7	24	11	10	7	10	11	5	3	2	2	12	6	4	2	3
	not relevant	2	2	1	1	3	2	3	2	3	3	2	4	2	4	1	0	1	1	1	1	1	1	1	1
	of no use	2	1	1	1	3	2	2	1	2	3	2	2	2	3	1	1	1	1	1	2	1	1	1	1
	not applicable	34	48	2	4	6	23	10	7	6	9	33	16	12	11	1	2	1	0	0	1	4	1	1	1
transfer	no	42	58	12	20	27	28	23	21	15	38	41	36	32	25	19	11	10	9	6	29	18	17	16	11
	yes	58	42	88	80	73	72	77	79	85	62	59	64	68	75	81	89	90	91	94	71	82	83	84	89
received	no	44	59	14	21	31	34	25	20	19	40	48	37	30	30	20	13	12	11	10	28	20	19	16	16
	yes	56	41	86	79	69	66	75	80	81	60	52	63	70	70	80	87	88	89	90	72	80	81	84	84
dialogue	no	47	67	18	34	32	38	29	25	22	51	58	48	44	40	24	18	16	16	13	41	34	31	30	16
	yes	53	33	82	66	68	62	71	75	78	49	42	52	56	60	76	82	84	84	87	59	66	69	70	84
in person	no	48	62	21	29	32	39	30	26	25	40	52	41	37	35	25	21	20	19	18	32	29	26	25	27
	yes	52	38	79	71	68	61	70	74	75	60	48	59	63	65	75	79	80	81	82	68	71	74	75	73
via phone	no	54	76	30	54	41	46	38	35	33	63	69	62	59	57	34	30	28	27	26	57	53	52	51	49
	yes	46	24	70	46	59	54	62	65	67	37	31	38	41	43	66	70	72	73	74	43	47	48	49	51
via email	no	43	60	14	23	25	33	23	20	18	36	48	37	32	30	17	14	12	11	10	27	23	20	19	17
	yes	57	40	86	77	75	67	77	80	82	64	52	63	68	70	83	86	88	89	90	73	77	80	81	83
decision	no	53	65	0	0	46	47	35	29	27	51	57	44	37	35	0	0	0	0	0	0	0	0	0	0
	yes	47	35	**100**	**100**	54	53	65	71	73	49	43	56	63	65	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix B. Table 2. Showing the data resulting from the Machine learnt Bayesian network analysis (MLBN) for the baseline scenario, scenario 3 and 4. The first column shows the factors that were analysed, which were represented by the nodes in the MLBN and column two represent their different states. Row one to three describe the theme of the chosen scenarios. Row four distinguishes between the two case studies: MoorFutures (MF) and Peatland Code (PC). Numbers represent the probabilities of the different status of the nodes in %. If one node was set as a target, the specific status is highlighted with 100% probability in bold.

	theme			frequency of communication												usefulness									
		baseline scenario		scenario 3												scenario 4									
	scenarios	baseline		no communication	once a year	twice a year	quarterly	monthly	weekly	no communication	once a year	twice a year	quarterly	monthly	weekly	of no use	not relevant	slightly useful	useful	very useful	of no use	not relevant	slightly useful	useful	very useful
	case study	MF	PC	MF						PC						MF					PC				
length of relationship (in years)	0	25	35	68	9	3	2	2	2	68	9	4	3	2	2	10	17	5	2	1	11	17	5	2	1
	<=1	7	7	2	14	14	10	8	6	2	14	14	10	8	6	15	10	21	14	5	15	9	21	15	5
	>1-5	29	27	19	34	35	35	34	32	19	34	35	35	34	33	31	26	38	36	32	28	29	38	35	33
	>5-10	19	16	7	23	25	26	26	27	7	23	24	25	26	27	25	27	21	25	28	24	26	21	26	27
	>10<20	12	10	3	13	15	17	19	20	3	13	15	17	18	20	10	10	9	15	22	11	9	9	15	22
	>=20	7	6	2	7	8	10	11	13	2	7	8	10	11	12	10	10	7	7	13	11	9	7	7	12
frequency of communication	weekly	10	5	0	0	0	0	0	**100**	0	0	0	0	0	**100**	9	9	3	6	24	5	4	1	4	18
	monthly	18	10	0	0	0	0	**100**	0	0	0	0	0	**100**	0	9	8	5	31	30	6	4	3	21	24
	quarterly	19	17	0	0	0	**100**	0	0	0	0	0	**100**	0	0	22	13	30	28	31	20	10	27	29	37
	twice a year	11	10	0	0	**100**	0	0	0	0	0	**100**	0	0	0	42	6	34	19	8	42	5	31	21	10
	once a year	8	10	0	**100**	0	0	0	0	0	**100**	0	0	0	0	6	32	25	13	4	8	36	32	20	7
	no communication	34	49	**100**	0	0	0	0	0	**100**	0	0	0	0	0	12	32	3	2	2	19	41	5	4	4
usefulness	very useful	31	22	2	16	24	49	53	78	2	16	24	49	53	78	0	0	0	0	**100**	0	0	0	0	**100**
	useful	24	19	2	40	42	34	42	14	2	40	42	34	42	14	0	0	0	**100**	0	0	0	0	**100**	0
	slightly useful	8	8	1	25	25	12	2	2	1	25	25	12	2	2	0	0	**100**	0	0	0	0	**100**	0	0
	not relevant	2	2	2	8	1	1	1	2	2	8	1	1	1	2	0	**100**	0	0	0	0	**100**	0	0	0
	of no use	2	1	1	1	6	2	1	2	1	1	6	2	1	2	**100**	0	0	0	0	**100**	0	0	0	0
	not applicable	34	48	94	9	2	2	1	2	94	9	2	2	1	2	0	0	0	0	0	0	0	0	0	0
transfer	no	42	58	92	51	22	15	4	4	93	55	28	21	7	6	27	50	28	19	12	38	62	37	29	21
	yes	58	42	8	49	78	85	96	96	7	45	72	79	93	94	73	50	72	81	88	62	38	63	71	79
received	no	44	59	94	44	27	18	7	7	95	47	32	23	9	9	65	65	41	18	8	64	70	46	26	13
	yes	56	41	6	56	73	82	93	93	5	53	68	77	91	91	35	35	59	82	92	36	30	54	74	87
dialogue	no	47	67	98	58	31	24	3	3	99	66	47	39	8	8	34	56	36	24	16	52	71	52	41	31
	yes	53	33	2	42	69	76	97	97	1	34	53	61	92	92	66	44	64	76	84	48	29	48	59	69
in person	no	48	62	99	33	46	29	3	3	99	33	51	29	4	5	40	49	46	25	17	49	59	40	31	24
	yes	52	38	1	67	54	71	97	97	1	67	49	71	96	95	60	51	54	75	83	51	41	60	69	76
via phone	no	54	76	99	75	36	38	13	9	99	83	54	59	30	23	42	65	28	35	26	63	81	66	57	49
	yes	46	24	1	25	64	62	87	91	1	17	46	41	70	77	58	35	72	65	74	37	19	34	43	51
via email	no	43	60	99	57	20	11	1	2	99	61	23	16	2	4	26	53	28	71	10	36	66	36	27	17
	yes	57	40	1	43	80	89	99	98	1	39	77	84	98	96	74	47	72	83	90	64	34	64	73	83
decision	no	53	65	95	56	44	30	21	16	95	56	45	32	22	17	79	79	75	33	11	75	82	76	35	15
	yes	47	35	5	44	56	70	79	84	5	44	55	68	78	83	21	21	25	67	89	25	18	24	65	85

Appendix C. Table 3. Showing the data resulting from the Machine learnt Bayesian network analysis (MLBN) for the baseline scenario, scenarios 5a-c, 6a-e and 7. The first column shows the factors that were analysed, which were represented by the nodes in the MLBN and column two represent their different states. Row one to three describe the theme of the chosen scenarios. Row four distinguishes between the two case studies: MoorFutures (MF) and Peatland Code (PC). Numbers represent the probabilities of the different status of the nodes in %. If one node was set as a target, the specific status is highlighted with 100% probability in bold.

	theme			mode of communication						one-way vs two-way										extra mentioned people			
		baseline scenario		scenarios 5a-c						scenario 6a		scenario 6b		scenario 6c		scenario 6d		scenario 6e		scenario 7			
	scenarios	baseline		in person		via phone		via email		transfer		received		dialogue		transfer 100%+dialogue and in person 0%		received 100%+dialogue and in person 0%		only case study		extra people	
	case study	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC	MF	PC
length of relationship (in years)	0	25	35	3	4	3	4	3	4	2	3	3	5	3	3	5	5	16	17	26	36	8	10
	<=1	7	7	10	10	9	10	10	10	9	10	9	10	9	10	9	9	10	10	7	6	10	9
	>1-5	29	27	34	34	34	34	34	34	36	38	34	34	34	34	51	51	33	33	29	27	33	33
	>5-10	19	16	26	25	26	25	26	25	25	24	26	25	26	25	18	17	20	20	19	16	24	24
	>10<20	12	10	17	17	17	17	17	17	17	16	18	17	17	17	10	10	14	14	12	10	16	16
	>=20	7	6	10	10	10	10	10	10	10	10	10	10	11	10	7	7	7	7	7	6	9	9
frequency of communication	weekly	10	5	18	13	19	16	17	12	16	11	16	11	18	14	1	1	2	1	10	5	11	13
	monthly	18	10	33	25	34	29	31	24	29	22	30	22	33	27	1	1	2	2	18	9	22	24
	quarterly	19	17	27	31	26	28	30	35	29	31	29	32	28	31	12	12	15	15	19	16	30	28
	twice a year	11	10	11	13	15	19	15	19	15	17	14	16	14	16	25	24	27	26	11	10	16	15
	once a year	8	10	10	17	4	7	6	9	7	10	8	13	6	10	11	11	17	17	8	10	12	9
	no communication	34	49	1	1	1	2	1	1	4	9	3	7	1	2	49	50	38	39	35	50	9	11
usefulness	very useful	31	22	49	44	50	47	49	45	47	41	51	47	49	46	16	16	31	31	31	22	41	42
	useful	24	19	34	35	34	34	34	35	33	32	35	35	34	34	21	20	29	29	23	19	33	31
	slightly useful	8	8	10	12	9	11	10	12	10	12	9	10	10	11	11	11	13	13	8	8	12	10
	not relevant	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	4	4	2	2	2	2
	of no use	2	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	3	3	2	1	2	2
	not applicable	34	48	3	4	3	4	3	3	6	10	3	5	3	4	47	48	19	20	35	48	11	13
transfer	no	42	58	13	22	11	19	12	19	0	0	12	19	7	8	0	0	60	61	43	59	19	19
	yes	58	42	87	78	89	81	88	81	**100**	**100**	88	81	93	92	**100**	**100**	40	39	57	41	81	81
received	no	44	59	16	23	14	22	15	21	15	22	0	0	10	12	65	65	0	0	45	60	22	22
	yes	56	41	84	77	86	78	85	79	85	78	**100**	**100**	90	88	35	35	**100**	**100**	55	40	79	78
dialogue	no	47	67	15	30	12	30	14	28	15	28	15	29	0	0	**100**	**100**	**100**	**100**	48	68	16	17
	yes	53	33	85	70	88	70	86	72	85	72	85	71	**100**	**100**	0	0	0	0	52	32	84	83
in person	no	48	62	0	0	18	25	21	28	22	30	21	28	16	20	**100**	**100**	**100**	**100**	49	63	29	29
	yes	52	38	**100**	**100**	82	75	79	72	78	70	79	72	84	80	0	0	0	0	51	37	71	71
via phone	no	54	76	28	52	0	0	25	47	30	54	30	54	24	49	74	76	70	72	54	77	58	47
	yes	46	24	72	48	**100**	**100**	75	53	70	46	70	46	76	51	26	24	30	28	46	23	42	53
via email	no	43	60	13	23	7	11	0	0	14	23	13	22	8	12	62	62	54	55	44	61	21	21
	yes	57	40	87	77	93	89	**100**	**100**	86	77	87	78	92	88	38	38	46	45	56	39	79	79
decision	no	53	65	29	34	28	32	29	33	28	33	27	32	27	30	61	62	56	56	54	65	37	37
	yes	47	35	71	66	72	68	71	67	72	67	73	68	73	70	39	38	44	44	46	35	63	63

Appendix D: Questionnaire questions

Q1 Are you (or have you been) responsible for policies regarding peatland ecosystems? (Yes/No)

Q2 What country are you from?

Q3 What institution are you working for?

Q4 Is the context of your work related to peatlands … (local, national, international, else)?

Q5 Where do you get your knowledge from, that you base your decisions on? (Scientists, Policy makers, Public, Media, Colleagues in your institution, Family, Friends, Others)

Q6 Please describe a recent decision you have made, based on communication you had with a researcher/researchers?

Q7 Thinking about the example in the previous question - What was most useful in the communication with the researcher(s) from your perspective?

Q8 Thinking about the example in the previous question - What was least useful in the communication with the researcher(s) from your perspective?

Q9 How frequently do you interact with this researcher? (it was the first contact, weekly, monthly, quarterly, twice a year, once a year, Other (please specify))

Q10 Please describe an interaction with a researcher/researchers that has decreased or increased (or both) your trust in research?

Q11 Could you tell me the top three pieces of advice you would give to researchers communicating with you or who you are communicating evidence with? (what do you find useful/not useful in communicating with researchers?, what do you find effective or not and why?)