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## **Co-constructing inclusive knowledge within converging fields: Environmental governance and health care**

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### *Abstract*

Ongoing complex global ecological and societal transitions pose challenges of including actors with different knowledge. We focus on approaches to gaining shared understanding and acting on it in the converging fields of environment, health care and environmental health. Starting from similarities between these fields with regard to knowledge and actor inclusion, we rethink 'knowledge', 'brokering' and 'science–policy interfaces'. Using conceptual models, we structure and characterize the multi-dimensional and interactive co-production and application of types of knowledge (scientific and other) in governance contexts shaped by institutions, political agency and policies (sectorial and integrative). We investigate cases of knowledge brokering, representing different types from formal to informal, international to national, and research-centered to action-oriented. We find both shared and isolated problems and solutions in the studied sectors and settings regarding knowledge brokering, for instance with respect to precaution, reflecting the dynamics in environmental and health care and their contexts. Methodologically, our analyses show the importance of heuristic and participatory approaches to explicating interpretations and dealing with disagreements about knowledge, values and premises for actions.

### *Keywords*

Environmental health; Sector coordination; Inclusiveness; Knowledge concepts; Science–policy interface

### *Highlights*

- We develop conceptual models for integrative and inter-sector knowledge brokering.
- We apply the models to compare various cases related to environmental health.
- Appropriate coordination of sector approaches depends on the context.
- There is conceptual convergence but also divergence of environmental and health care.
- Reflective and inclusive approaches help resolve disputes and clarify action premises.

## 1. Introduction

Ongoing global transitions and complex environmental and social changes pose challenges also in terms of including multiple relevant actors with different interests and abilities in policy deliberations. In addition to official institutions, various other actors participate in governance, and institutions have increasingly stressed the need for such inclusiveness (CEC, 2001, WHO and UNEP, 2008). However, established practices favoring relatively few groups of knowledge providers and types of knowledge are hard to change (Gornitzka and Sverdrup, 2011). For example, a review of knowledge brokering within environmental health revealed that almost half of the 67 assessed tools were used only by experts (Liu et al., 2012). Attempts to widen the circle of actors and the knowledge base may be sidelined by democracy deficits, social upheavals, financial crises and technological transitions.

As policies in democratic societies are largely about knowledge claims, the processes and issues within the generation and application of knowledge become critical (Juntti et al., 2009). The role of knowledge and the conduct of knowledge management take on new aspects with the development of science and technology, notably for information and communication, and of society at large. New ways of learning and unlearning develop for instance due to social media (Lyytimäki et al., 2009). It is no wonder that knowledge and its foundations, uses and impacts become contested in new ways as shown by debates on global issues such as climate change (Skrydstrup, 2009) or on local issues such as environmental and health effects of new solutions for groundwater use (Lyytimäki and Assmuth, 2014). Thus, knowledge “brokering” or, rather more generally, the deliberation, negotiation and associated co-construction of knowledge, becomes a key function in societies, in the relationships between actors and in their interactions with the environment (Jasanoff, 2004).

Knowledge brokering (KB), a relatively recent approach for deliberating and negotiating on knowledge (Barkley, 1991, Thompson et al., 2006, Lomas, 2007), has developed rapidly in areas that are knowledge intensive and where the evaluation and translation of evidence to applications is crucial (Holzmann, 2013). Different types and purposes of KB have been identified, from synthesizing and checking evidence to legitimation of actions. Various approaches have been utilized in relation to environmental protection (Michaels, 2009), while most systematic use and also scrutiny of these methods have taken place within public health (Urquhart et al., 2011, Chew et al., 2013, Lavis et al., 2013, Ridde et al., 2013).

Knowledge brokering involves several contested questions ranging from choices of appropriate communication tools to power relations. Some models of the relationships of actors in knowledge brokering or co-construction, for instance in risk analysis and governance (Jasanoff, 1993), have been considered simplistic (Horlick-Jones and Sime, 2004). Even the fundamental ontological concepts of knowledge have varied widely, along with the overall theoretical and methodological inclinations, ranging from positivist to constructivist and relativist notions. Critiques of positivism have been offered e.g. from perspectives of information systems (Boland and Pondy, 1983) and of science in society (Asdal, 2005, Felt et al., 2007), both emphasizing inter-subjectivity.

In responding to these challenges, there is a need to replace linear with dynamic and positivist with reflective models of knowledge construction, use and loss (Lyytimäki et al., 2009, Assmuth and Finkel, 2014). Specifically, better understanding is needed of how multi-actor governance and associated dynamic negotiation over knowledge reshape the horizontal integration of sectors,

prompting many forms of inclusive deliberation. Likewise, pragmatic models of KB need to be developed. In this article we review approaches and investigate issues in developing KB and in co-constructing inclusive knowledge in its multiple meanings.

## **2. Methodological approaches and scope**

We focus on approaches to gaining and acting on knowledge in the converging fields of environment and health care and their border-zone, environmental health. We note as a starting point similarities between these fields with regard to inclusion, e.g. in holistic knowledge, in combining individual and collective views for pluralism, and in ethics that are extended to future generations, humanity, and non-human organisms (Assmuth et al., 2010, Assmuth and Finkel, 2014). We scrutinize 'knowledge', 'brokering' and 'science–policy interface' emphasizing inter-subjectivity and collective rationality (Habermas, 1984), moving from linear to dynamic models of knowledge accumulation and loss. We challenge not only narrowly positivist 'social engineering' approaches to knowledge but also alternatives that deny the need for pragmatism and normative frames (cf. Surel, 2000).

We develop conceptual models based on earlier work, in order to highlight the relevant features of KB related to environmental health. The models include those of governance contexts (e.g., Jordan et al., 2003) and of science–policy interfaces (e.g., Hammill et al., 2013). We examine in what contexts and processes KB of various kinds takes place. Specifically, we pay attention to the criteria for evidence (of problems and solutions) and to associated interpretations of precaution, based in part on different requirements for proof and competence (heavily regulated in medicine) to check claims, projections and advice.

We complement the conceptual analyses by case studies and observations based on our participation in projects involving KB. At the EU level, we investigate the EEA's Environmental Health Narrative as an alternative to factual monitoring based assessments. We then discuss KB spanning sectors, levels and stages of governance in the case of dioxins in Baltic Sea fish. At the national level, we analyze mandatory KB in Environmental Impact Assessment and Health Impact Assessment in Finland, and a concrete KB tool *Opasnet.fi*, an open platform by the Finnish National Institute of Public Health and Welfare.

## **3. Conceptual models of sector relationships in knowledge brokering**

We first conceptualize the multi-dimensional and interactive co-construction (co-generation) and co-application of types of knowledge (scientific and experiential, also value-laden), in multi-actor governance within partly overlapping sectors such as human health care and environmental management (Fig. 1). This multi-sectorial governance model is situated in an ecological and socio-political context which includes the dimensions of politics (political institutions and agencies); policies (sectorial and coordinative); and, going beyond self-sufficient and 'empty' governance (Jordan et al., 2003), politics within these. Framing of the system with regard to practical functions and to knowledge, we relate it to other policy domains, other scientific and professional disciplines, and other societal concerns.

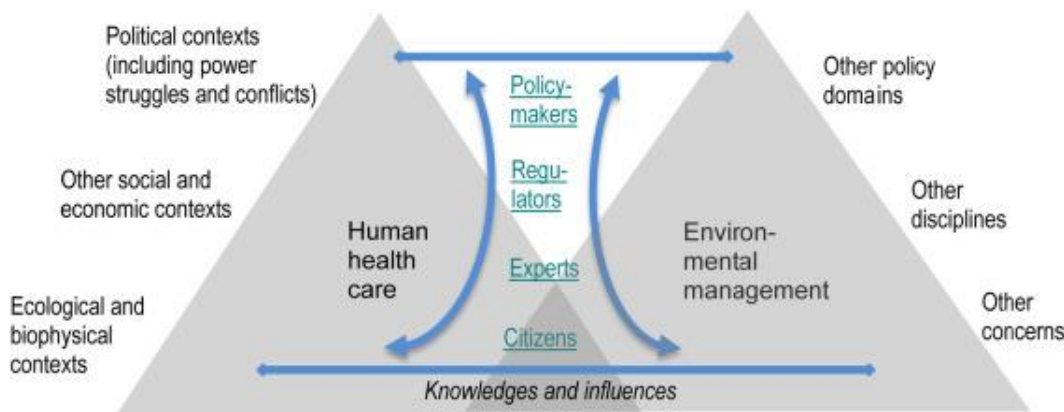


Fig. 1. A simplified structure of multi-actor governance in environmental management and human health care. The sectors, actors and domains are in fact not separate and hierarchical but partially overlapping.

Focusing on Europe, the institutions include democratic, elected representations and delegated bodies and agencies of the EU and its Member States, public research institutes and expert organizations, and increasingly also non-governmental actors such as representatives for enterprises and other non-governmental or civil society organizations (Fig. 2; Knill, 2001). This structure is generalizing; environmental and health governance varies between countries and settings (WHO-Europe, 2009) and is also dynamically developing, e.g. so that in the European Parliament these sectors are represented by one Standing Committee and in some countries these sectors are fused, at least on some (such as municipal) level.

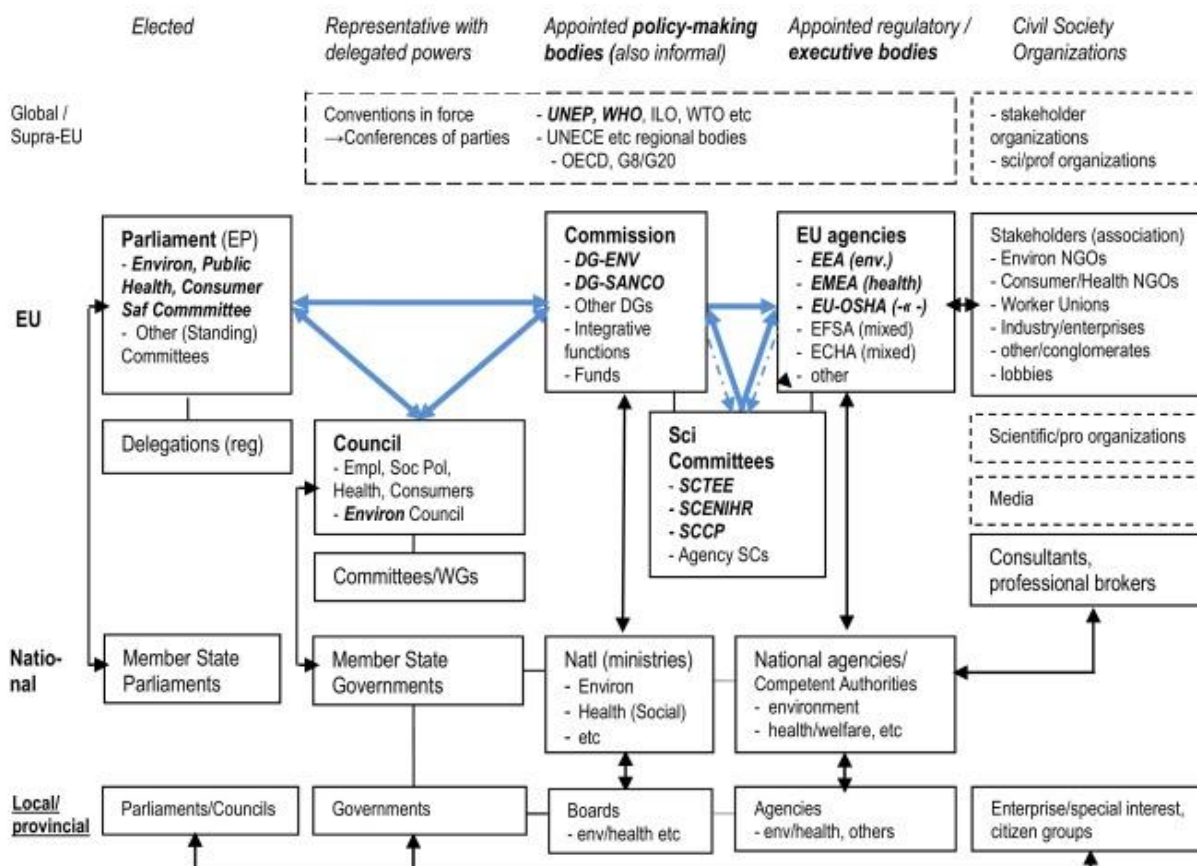


Fig. 2. The institutional setting of the interaction of environment and health sectors in EU and Member State governance between supra-EU and local levels (modified from Assmuth et al., 2010). Principal influences and affiliations are shown by arrows and lines, focusing on official influences. Note the 'power' triangle to the left and the 'knowledge' triangle to the right, shown by bold arrows, and that influences are based variably on knowledge.

Regarding the actors and processes involved, we postulate that the multi-actor governance and the associated dynamic contestation of knowledge reshape the horizontal integration of sectors, prompting partly new forms of deliberation between, within and around the sectors (Fig. 1, Fig. 2). There is a need for both diversification and convergence in the interaction and coordination between sectors. In some cases and in some respects, deep integration is needed and viable, while in others the sectors may retain the particularities in their actions, including the co-generation and co-use of knowledge. For instance, KB tools in environmental health often focus on only one environmental stressor or one disease, calling for greater integration (cf. Liu et al., 2012). However, the principles and procedures also in evaluating evidence and knowledge may differ much between these sectors, depending on the context (cf. Assmuth and Hildén, 2008, Assmuth et al., 2010) so that categorical integration is not justified.

The integrative solutions also depend on the administrative configurations and resources that have historical, structural and other contextual determinants. For instance, in some countries environmental and health administrations or their expert bodies have been formally integrated at least at some level, in others not. The starting points for integrative KB are then very different.

Regarding the interpretations and functions of knowledge and KB in these interactions, we conceptualize it as (partly) open and dynamic multi-directional processes in different stages or areas in the interactions between R&D and application (Fig. 3). This model is informed by previous analyses e.g. of Hammill et al. (2013) but we detail the interactions further. Near the scientific realm (left), KB is concerned with multi-disciplinary integration, near the application realm (right) with inter-sector and action-analysis integration. In the latter realm in particular, normative and binding brokering (here called 'hard' brokering) occurs, as opposed to 'soft' knowledge brokering that dominates in research-driven end of the continuum. KB can further be divided based on notions of knowledge (expert-dominated 'objective', or more inclusive and participatory involving inter-subjectivity).

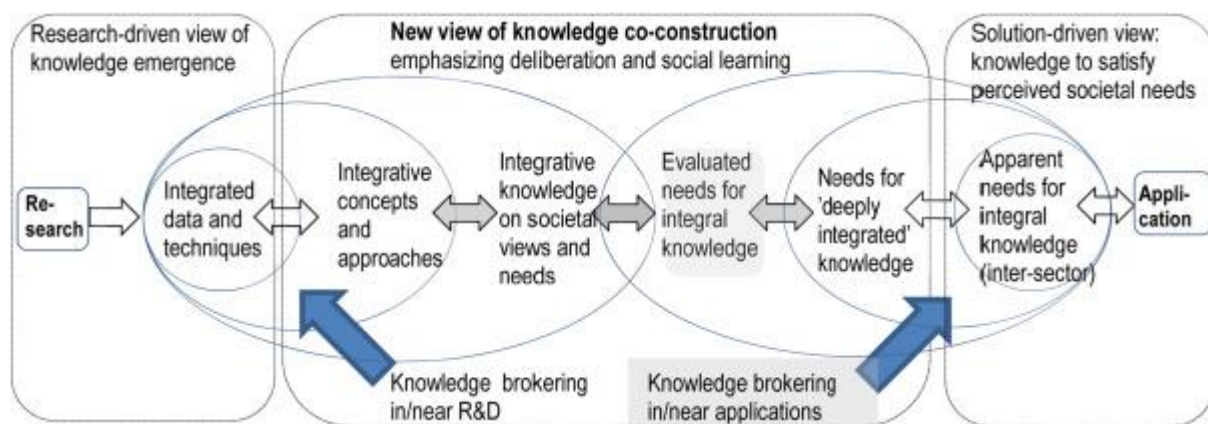


Fig. 3. A functional model of knowledge brokering between research and societal application, emphasizing integration on successive levels. Modified from Assmuth et al. (2009).

Based on these conceptualizations and on earlier studies, we summarize some of the key areas and issues in the contents and contexts of KB within and between the environment and health care sectors and in their relationships with other sectors (Table 1). We focus on the overlapping

domains of co-construction of knowledge and of participation, and on the integration or coordination of the sectors especially in knowledge synthesis and use.

Table 1. Key processes, issues and relationships of health, environment and adjacent sectors, emphasizing scientific and societal conditions for knowledge brokering, and integrative processes on national and EU levels.

Sector/field	National intervention	EU intervention	Knowledge processing issues	Issues of agency and participation in knowledge brokering	Integration of environ/health (impacts/risks/choices)
Environment	High (some areas)	Low to high (norms – economic steering – information)	<ul style="list-style-type: none"> <li>- IA<sup>a</sup> (ex ante/post) framing</li> <li>- Dealing with uncertainty</li> <li>- Proofs of impacts/means</li> <li>- Foresight for resilience</li> <li>- Experiments (trial &amp; error)</li> </ul>	<ul style="list-style-type: none"> <li>- Equity (harms, benefits)</li> <li>- Conflicting interests</li> <li>- Differing concepts of reality</li> <li>- Balancing agendas with reflection and deliberation</li> </ul>	<ul style="list-style-type: none"> <li>- Multi-stressor</li> <li>- Multi-media</li> <li>- Adaptability for sustainability</li> <li>- Environ policy integration<sup>c</sup></li> <li>- Balancing agendas</li> </ul>
Health	High	Low to moderate (some norms and information)	<ul style="list-style-type: none"> <li>- Synthesizing data/HIAs<sup>b</sup></li> <li>- Etiological causality</li> <li>- Therapy effectiveness</li> <li>- Health promotion means</li> <li>- Health systems evaluation</li> <li>- Precaution vs. evidence</li> </ul>	<ul style="list-style-type: none"> <li>- Authority-interactivity in patient advice</li> <li>- ‘Life decision’ accountability</li> <li>- Personalized health</li> <li>- Equity in health access</li> </ul>	<ul style="list-style-type: none"> <li>- Multi-factoriality</li> <li>- Environ. health coordination</li> <li>- EIA-HIA fusion<sup>d</sup></li> <li>- Synergy/tradeoffs</li> <li>- Integrated food &amp; water safety<sup>e</sup></li> <li>- Health in All Policies<sup>f</sup></li> </ul>
Citizen security	High	Low	<ul style="list-style-type: none"> <li>- Experience for foresight</li> <li>- Surveillance vs. privacy</li> </ul>	<ul style="list-style-type: none"> <li>- Individual/collective</li> <li>- Social security &amp; trust</li> </ul>	<ul style="list-style-type: none"> <li>- Integrated preparedness + control</li> </ul>
Agriculture + veterinary	High	High (subsidies)	<ul style="list-style-type: none"> <li>- Food chain sustainability</li> <li>- Nutrition/diet information</li> <li>- Ecological knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- Farmer, consumer and industry engagement</li> <li>- Risk/benefit equities</li> </ul>	<ul style="list-style-type: none"> <li>- “One Health” (ecosyst. health)<sup>g</sup></li> <li>- Food-feed quality<sup>h</sup></li> <li>- Natural, social health factors<sup>i</sup></li> </ul>
Fisheries	Low to medium	High; norms, subsidies	<ul style="list-style-type: none"> <li>- Planning for sustainability</li> <li>- Uncertainty management</li> </ul>	<ul style="list-style-type: none"> <li>- Stock co-management</li> <li>- Social aspects of fishing</li> </ul>	<ul style="list-style-type: none"> <li>- Sustainable fisheries</li> <li>- Integral coastal/marine policy</li> </ul>
Industry	Medium	Medium; norms, subsidies	<ul style="list-style-type: none"> <li>- Corporate planning</li> <li>- Knowledge (as) industry</li> <li>- Confidentiality</li> </ul>	<ul style="list-style-type: none"> <li>- Labor health/labor effects</li> <li>- Global to local impacts</li> <li>- Rights to know</li> </ul>	<ul style="list-style-type: none"> <li>- Integrated product policy</li> <li>- Environ, health, safety</li> <li>- Total quality</li> </ul>

Sector/field	National intervention	EU intervention	Knowledge processing issues	Issues of agency and participation in knowledge brokering	Integration of environ/health (impacts/risks/choices)
Energy, climate	High	Low; support, norms/standards	- Supply/demand balances - Network paths/impacts - Radical uncertainty	- Energy poverty/power - User/producer relations Plans vs. panic/paralysis	- Fuel cycle/system reliability - Energy policy integration - Climate change IA & adapt
Transport	High	Low; econ; norms	- Links with social structure - Mode shift/choice	- Transit needs and access - Collective transit benefits	- Integral safety - Integral sustainable mobility
Common market	Low	High; norms	- Trade process modeling - Market analyses	- Consumer claims - Markets as driver/target	- Harmonization - Trade-risk links
Economy	High	Low; econ, norms	- Macro/micro equilibria - Processes and paths	- Decouple growth/welfare - Actor behavior	- Integral security, insurance - Market + regulation
Development	Medium	Medium; funds	- Indicators (env, health etc.) - Indigenous knowledges	- Community-based dev. - Health/ecosystem links	- Multi-level integration - Multi-sector integration

<sup>a</sup> IA = integrated assessment. <sup>b</sup> HIA = health impact assessment. <sup>c</sup> Herodes et al. (2007). <sup>d</sup> EIA = environmental impact assessment; BMA (1998), Bridges (2003) and Briggs (2008). <sup>e</sup> Dreyer et al. (2010) and Parkes et al. (2010). <sup>f</sup> Dora et al. (2013) and Leppo et al. (2013). <sup>g</sup> Zinsstag et al. (2005) and Barrett et al. (2010). <sup>h</sup> Rajić et al. (2013). <sup>i</sup> Dreyer et al. (2010).

Modified and updated from Assmuth et al. (2010).

Several common and some deviating processes and factors in KB can be discerned in the various sectors, both regarding knowledge-focused and political processes such as those of participation and agency, depending also on the level of supra-national intervention (Table 1). This means that there are also needs and opportunities for integration of and mainstreaming approaches, in a process of broad multi-sector and multi-actor learning.

## 4. Cases

### 4.1. 'EEA's 'Environmental Health Narrative'

The 'Environmental Health Narrative' being developed by the European Environment Agency (EEA) is an example of 'soft' KB (see above) involving the interaction between research and other knowledge activities (monitoring, testing, assessment etc.) on one hand, and between these two sectors of governance at various levels (mainly EU and national). The EEA, as an expert organization of the EU, particularly the Commission and Member States, is functionally situated

between monitoring and the formulation and implementation of environmental policies. EEA thus focuses on decision support by 'soft' brokering with limited powers of enforcement (Hoornbeek, 2000, Martens, 2010). Increasingly, it endeavors to link environmental management with other societal sectors (EEA, 2005a, EEA, 2005b). This is ongoing also within environment and health.

The narrative focusing on health in the context of the EEA's State Of the Environment Reports can be interpreted as an attempt to develop assessments focused on emissions of hazardous substances toward a broader content encompassing positive health aspects of environments (DG-SANCO, 2003, Morris et al., 2006). It also aims at a style better able to 'speak to publics', moving from formal expert knowledge to a more experiential and even emotional representations of knowledge to catch people's attention and engage them.

In developing the narrative there has been some tendency to agenda-driven or message-driven framings (EEA, 2013b). Likewise with 'late lessons' of precaution (EEA, 2013a), 'true warnings' have been stressed instead of 'false alarms' (Mazur, 2004) or instead of a more balanced assessment also of unintended consequences of actions thought to be precautionary. In terms of the KB process, this is reflected in the increasing separation of summary conclusions from more extensive and many-sided analyses.

#### **4.2. Environmental impact assessments and health impact assessments**

Impact assessments serve as tools for co-constructing knowledge for policy-making, planning and associated resolution of conflicts. Environmental Impact Assessment (EIA) procedures have been established for facility-level and later for policy and strategic level assessment. Health Impact Assessment (HIA) practices have been developed and adopted also on local level (Hübel and Hedin, 2003, Lee et al., 2013). They have been used also in evaluating other sectors, e.g. with the Health in All Policies initiative of the WHO (Leppo et al., 2013). There are important similarities between these forms of assessment, including their configuration as processes where all stakeholders impacted by a scheme are meant to be included. Conceptual convergence is notable also with integrated risk assessment (Assmuth et al., 2010) and with Drivers, Pressures, States, Impacts & Responses (DPSIR) analyses, e.g. in "DPSEEA" framework including exposures, effects and actions (Corvalán et al., 1996).

Such processes face common issues: framing of alternatives and consideration of options; various aspects of impacts, also socio-psychological (Gee and Payne-Sturges, 2004); indirect, uncertain and unintended consequences; suited indicators (von Schirnding, 2002); explication of value judgments in allegedly neutral facts; resolution of conflicting views and interests; agency and power in defining goals and conduct; and anticipation and follow-up of changes. HIA, EIA and other assessments can thus cross-fertilize each other (BMA, 1998, Dora, 2003, Sekizawa and Tanabe, 2005), also better linking with social impact assessment (Dreyer et al., 2010) to develop integrated assessments that are sufficiently inclusive.

All these issues are notable in the EIA process for the artificial groundwater recharge scheme in Virttaankangas aquifer, Finland. The health concerns were here highlighted by media debates but not much by the EIA or comments given to it (Lyytimäki and Assmuth, 2014). Despite the science-based knowledge indicating no major health concern, the risks from mercury in sediments of the river serving as the raw water source were intensively discussed. This shows the importance of taking into account all discussion forums in addition to mandatory ones. Also concerns for the



long-term safety and feasibility of the water provision solution were expressed. While some of these concerns were exaggerated, those in favor of the scheme may on the other hand have been inclined to downplay them. As such, the case highlighted polarized notions of impacts and risks and of relevant knowledge. These deviating notions go beyond obvious gaps in the health effects assessments in EIA (Steinemann, 2000, Hübel and Hedin, 2003) and may reduce them to “educated guesses” (Harvey, 1990).

### **4.3. Dioxins in Baltic Sea fish**

As an example of the complexities and challenges in KB between sectors as well as levels of governance, the case of dioxin-like compounds (including other persistent bio-accumulating toxicants) in Baltic Sea fish is instructive (Assmuth and Jalonen, 2005, Assmuth, 2011, Assmuth and Finkel, 2014). It exemplifies the influence of contextual and situational factors on governance: dioxins are a high-profile issue due to recurrent international scandals of dioxins in food which, being a threat to the safety and trustworthiness of a major industrial branch of the EU and to its core idea of the common market, prompted strict regulations on the maximum allowable levels of dioxins and PCBs in food and feeding-stuffs.

The institutional setting involves, beyond actors within environmental management, health and consumer safety (including food and nutrition), other sectors such as fisheries and industry, with partly conflicting interests. Also the interests of the EU and its members differ: the governance issue involves the justifications for derogations from the EU limit values allowed to Sweden and Finland, based on health arguments (benefits from fatty fish) as well as on socio-economic arguments and on risk controls already taken. It thus highlights the limits of the subsidiarity principle. Because dioxins due to their persistence are ubiquitous and as accidental reaction products have no single source, their management involves many options and stages along their life-cycles, from prevention of their formation to exposure reduction through diet advisories and limit values in foods. Intakes have been much reduced from peak levels (in 1970's), but lagged effects (also on the offspring of those exposed) are still possible, especially in sensitive sub-groups (Assmuth, 2011).

Consequently, KB in this case has taken place on many levels from EU-wide to national and regional (e.g., the Nordic Council of Ministers and HELCOM) and in many forms, from assessments by official bodies to specific projects. However, most assessments (see references in Assmuth and Jalonen, 2005) have focused on specifics of toxicological risks – yet without arriving at non-equivocal estimates of their magnitude and of the safe intakes – instead of analyzing management and governance options. Options analyses could include, for better sector coordination, conflict resolution and governance in general, such key issues as synergies and tradeoffs between strategies (cf. Brunner et al., 2009); distributions of risks and benefits, and ‘no-regret’ opportunities for avoiding dioxins while securing benefits; and political principles in imposed or voluntary risk reduction (Assmuth and Finkel, 2014).

Knowledge brokering, though extensive and expanding to cover some (mainly technical) management aspects, has thus in this case been biased to collating evidence from research and monitoring, instead of deliberating on their meaning, implicit value judgments, and goals, means and consequences more broadly.

#### **4.4. Opasnet.fi platform**

Opasnet is a wiki-based website and workspace for assisting societal decision making (<http://www.opasnet.org/>). It is an open platform for knowledge co-construction and deliberation (Pohjola, 2013). The website collects, synthesizes and distributes scientific and other factual information. It welcomes anyone who wants to engage in or promote fact-based decision-making. The platform aims to structure information simultaneously for scientific scrutiny and for policy and other use, including deliberation among interested parties. In practice, a user can do research, store and display data, make and run models, and perform assessments, and discuss all of that work in one workspace. The developers have been applying the platform e.g. to climate change and air pollution, generally with an environmental health focus, but as a multi-purpose work environment it can facilitate assessment of any topic and decision.

Applications have taken place e.g. within the project CONPAT (Contaminants, Pathways, Health risks and management), using Opasnet for cross-disciplinary and inter-institutional knowledge sharing and creation of common understanding. The experiences show that such a platform can be an efficient tool for these ends, but a relatively high level of motivation is required to learn to use it. Such motivation can be easily created in a research project but involving other actors such as policymakers or lay people is a challenging task.

As an open platform, Opasnet.fi does allow the communication and collaboration of both health and environmental as well as other professionals and actors associated with these. As such, it enables inter-sector and inter-actor involvement in “soft” KB. Although such an unofficial platform does not (even attempt to) formally and strongly coordinate sectors in organizational terms, due to its architecture and functionalities it can indirectly promote also this kind of coordination, e.g. through the development of shared concepts and exchange of information and views. For instance, common as well as differing issues in the environment and health fields regarding both scientific results and the societal context such as actor involvement could be identified in a learning process (cf. Saarikoski, 2000).

### **5. Discussion**

#### **5.1. Types and dimensions of knowledge brokering**

The types of knowledge considered legitimate in KB vary, and even scientific knowledge covers besides ‘exact’ and ‘objective’ information also more interpretative elements. Brokering essentially includes experiential knowledge of those involved (Fig. 4). Such multi-dimensionality of the knowledge(s) that are considered relevant, and the realization that all are influenced by subjectivity and self-interest, may lead to the erosion of authority and of idealized value-neutral ‘honest brokers’.

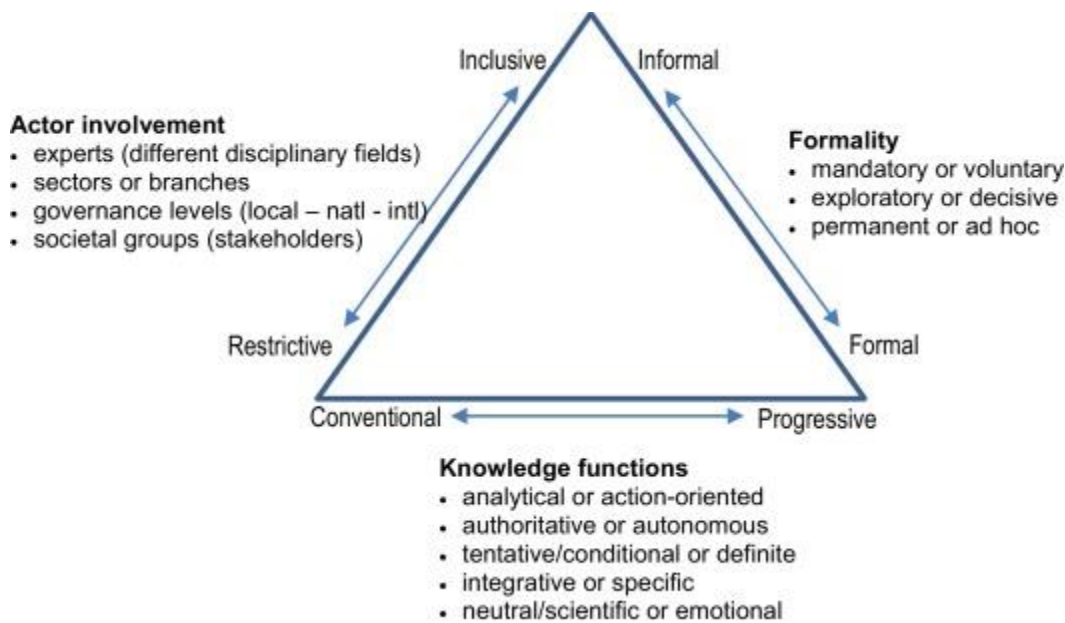


Fig. 4. Integrative typology of knowledge brokering along the key dimensions: governance actors, knowledge functions, and formality of procedures. Note that there are intermediates and hybrids between these polarities.

This multi-dimensionality may however also help to ground decisions in widely debated and more comprehensive knowledge, including explicit value judgments based on reflective approaches (Craye et al., 2005), on many-sided communication (IRGC, 2009) and on participatory deliberation (Wright et al., 2005a). Thus, the actor involvement dimension in Fig. 4 is crucial; inclusive brokering can essentially complement traditional expert-driven dimensions of knowledge functions and formality.

The development of shared concepts is a key to KB in a complex and inter-connected world characterized by changing environmental and health conditions and challenges. For instance, ecosystem health concepts have evolved to link environmental assessments with human health (Butler and Oluoch-Kosura, 2001, Brunner et al., 2009), and have been extended to “One Health” integrating human, domestic animal and wildlife health (Kaplan et al., 2009). Environmental and health integration has also come into focus with ecosystem services, and “Green care” has taken such concepts to active interventions. These exemplify the dynamic development in integration and in associated knowledge brokering, also in the contents and relative positions of its key dimensions (Fig. 4; see also Assmuth et al., 2010). This leads us to consider the dynamics in reaching shared or diverse views in knowledge brokering.

### 5.1.1. Impediments for shared views of knowledge

Lavis et al. (2013) identified problems in KB for health systems development in the EU: lacking use of information on these systems in policy-making; lacking use of promising KB means such as policy briefs, dialogs and good practices; lacking support for KB (cf. LaRocca et al., 2012). Important structural and contextual problems can be added, such as the compartmentalization, bureaucracy and capacity of policy-making and implementation (also in terms of willingness and ability to engage in dialog). In health care as in other sectors, the lack of capacity is a critical factor with increasing austerity on one hand and requirements for quality, on the other. Coordination of and cooperation between sectors, emphasis on prevention of problems in all of them, and tailoring of services (also from ecosystems) to fit the most crucial needs are partial solutions.

However, as can be seen in some of the cases, there are obstacles to these also within the KB needed in and between the sectors (Table 2). Potentially still more important and hard-solved, there are genuine conflicts of values, interests and powers. On the positive side, KB can help to resolve these as well.

Table 2. Summary characterization of knowledge brokering dimensions and issues in the cases studied, with particular relevance to balanced convergence of the sectors of environmental governance and health care.

Case	Type/purpose	Level of governance and normativity	General policy issues	Horizontal integration issues	Actor inclusion issues	Precaution issues
EEA environment and health narrative	Inform and engage key players and publics	EU and national; peri-normative	Shifting foci in governance; societal and environmental challenges	Environment and health (increasingly)	Experts and regulators (+IGOs), later publics	Uniting evidence-based (traditional health) and pre-cautionary policy
EIA, HIA and related strategic impact assessments	Regulatory steering, democratic conflict resolution	Local (facility IA) to international (strategic IA); normative	Shared goals; consideration of options; impact quality and targets	Limited	In principle, all those affected; in practice, dominated by strong players	In principle dealt with (risk/uncert. analyses and overall design), little in practice
Opasnet.fi platform	Knowledge tool and work environment	National to local (potentially supra-natl); non-normative	Big policy/political issues are dealt with indirectly but can be aided by dialog	Implicitly allowed; so far, health sector has dominated	Potentially broad, now expert and planner dominated; capacity issues for discourse and engagement	Can be dealt with explicitly, explicating evidence and arguments
Baltic Sea fish dioxins risk assessment and management	Mixed, from mandatory monitoring to some strategic analyses	EU, regional and national; mixed (from normative to informal)	As with EIA and HIA procedures	Relatively broad but some sectors only included (e.g., fisheries)	All key players (regulatory), others on ad hoc basis; capacity and interest issues (also multi-level governance)	Have been dealt with selectively (toxic risks more than benefits)

Some of the impediments of KB aiming for shared views have justification, partly because the sectors have differences not just in their history but also in their sustained mandate and role. For instance, the life-and-death decisions also on individuals in health care may presuppose absolute or at least different kind of expert authority, as well as is some respects different kind of knowledge brokering amongst experts and between experts and clients or decision-makers, than is common in e.g. environmental management. Harmonization of knowledge and views, also

value-based, thus needs to be balanced with the requirement of specification and of respect for deviating views.

As seen in all the above cases, there are tensions between integration and independence and between transitions or generally changes and continuity, and consequently limits to how far and how rapidly integration can proceed. This is akin to the balancing such competing goals in coordination of governance, vertically, horizontally and in terms of inclusion in general (Assmuth et al., 2010).

Based on our conceptual models and cases we identified several specific impediments for shared views and agreements on knowledge in KB processes involving environmental management and health care (cf. Table 1, Table 2):

- Conceptual divides due to different notions of knowledge (positivist, constructivist and beyond), implying needs to cross the fact-value divide (Putnam, 2002), as well as due to different perceptions of society and governance such as engineering-bureaucratic or participatory (“knowledge functions” and “actor involvement” dimensions in Fig. 4).
- Research-oriented KB in environmental health is still dominated by traditional paradigms focused on threats to health (DG-SANCO and SCHER, 2006) instead of multi-attribute well-being (DG-SANCO, 2003, DG-SANCO, 2008, Parkes et al., 2003, Morris et al., 2006, Spickett et al., 2012) (“knowledge functions” dimension).
- Differing interests and competitive positions due to sector goals, both genuinely distinct and tactical, implying the simultaneous convergence and divergence of goals (“actor involvement” dimension);
- Rigid institutional setups and sector policies, impeding coordination (inertia), especially with increased complexity of issues and governance processes, and diminishing resources (“formality” dimension).
- Disciplinary and sector cultures regarding knowledge, connections between research and practice (e.g., clinical) and precaution, and the requirements for expert authority (“actor involvement” dimension).
- Contextual drivers in technology and society (e.g., ‘big data’ and needs for syntheses).

### 5.1.2. Modes of inclusion in knowledge co-construction

Inclusion in brokering depends on perceived needs, access to KB processes, and respective societal arrangements and incentives. Based on our analysis of development needs and obstacles for improved KB in and between the sectors of environment and health care, the following opportunities or development areas in inclusive co-construction of knowledge and in associated inter-sector integration or coordination could be identified (Table 2, cf. Fig. 2):

- Horizontal: Engaging multi-sector multi-disciplinary teams and networks for KB. Specifically, in addition to KB within sectors, broader KB and generally discourse between environmental governance and health care and related sectors is needed.
- Vertical: Coordinating the interaction between local and upper-level actors.
- Multi-actor: Including experts, regulators and others such as service providers and clinical workers (Gerrish et al., 2011) in knowledge networks (Conklin et al., 2013); facilitating interaction and clarifying roles; and including lay insights (Callon, 1999).
- Reflectivity: Moving from ‘neutral’ processing of knowledge to action, and back, toward strategic (environmental) assessment (Wright et al., 2005b, Morris et al., 2006), thus

complementing traditional approaches to KB also in environmental health (CEC, 2004) and uniting concepts and practice (Kello et al., 1998, Hübel and Hedin, 2003).

## **5.2. Interpretations and operationalizations of precaution in relation to evidence**

Successful knowledge brokering helps to resolve or prevent disputes about the appropriate precaution in relation to evidence. This balance is affected by the field and context (de Sadeleer, 2006), but it is generally easier if genuine unconditional brokering on the pros and cons of precaution can take place. The type of brokering common within health care where knowledge is processed for discussion e.g. through synthetic reviews may help as an evidence and 'reality' check (Campbell et al., 2011), and may become more common also in the field of environmental management where penalties for excessive precaution are not as immediate and irreversible as with life-and-death decisions (Table 2). On the other hand, KB can involve new types of foresight through identification of emergent issues (IRGC, 2009).

In all the cases studied here, though in different ways, there were tensions between a traditional quasi-neutral collation and processing of knowledge in the form of 'scientific facts' and proven methods of inference on one hand, and 'action knowledge' more concerned with values, choices and means of reaching goals, on the other. This is conspicuous with the precautionary principle and preventive health (and environmental) care (Table 2).

For instance with dioxins, interpretations of precaution and of goals to achieve it differed also between sectors: the health profession was generally more focused on evidence of harm and on the proven beneficial effects of fish consumption, the environmental profession on proactive policies, partly based on other concerns with chemicals, also eco-toxicological (Table 2, Assmuth and Jalonen, 2005). However, notions of risks and impacts and evaluations of knowledge have differed widely also within these sectors.

These tensions require new heuristics for synthetic solutions combining reflection with experimentation and other measures based on core values and political will. In the present connection, we have noted how such solutions also presuppose multi-actor and multi-level brokering and negotiation. In relation to narratives of environmental health e.g. in the EEA, 'structured precaution' has been proposed as an approach ensuring the use of evidence (Cocco, personal communication).

## **5.3. Implications for research, methods development and innovation**

Many methodological challenges and opportunities in KB could be identified in both sectors, in their interactions and in their relations with other sectors. Some opportunities have been known for long (Go, 1987). The key challenge is about balancing: breadth and focus; roles and powers of actors; precaution and evidence; expert and lay views; collective and individual emphases; and communication both on risks and opportunities (IRGC, 2009).

These balancing acts gain importance in mainstreaming environmental and health policies, and in practical applications (Morris et al., 2006). Institutionalized deeper trans-disciplinarity including futures analyses are needed for such balances (Kahn, see Aligica, 2004). As shown above, the

depth of integration and also the appropriate methods will yet depend on the context and purpose of KB (Hübel and Hedin, 2003, Assmuth and Hildén, 2008).

Many platforms and tools for KB serve inter-sector integration and convergence that allow diversity. Broader involvement would require additional resources and other preconditions to 'reach and teach' the relevant stakeholders and especially to enable dispute and conflict resolution in the form of genuine brokering between competing interests. In such broader involvement and assessment, KB methods in both health care, where negotiation of scientific evidence is advanced, and environmental governance have plenty to offer each other.

## **6. Conclusions**

There are both shared and special problems and solutions in the studied fields or settings regarding KB, reflecting the roles of environmental management and health care as ambiguous and dynamic fields. There is conceptual and functional convergence between these fields. However, there are limits to their practical integration, of which particularly health care is firmly established. Some limits pertain to differences in concepts or principles, others are political or practical. The appropriate level and manner of integration of sector approaches, e.g. in coupling evidence and precaution, depend strongly on the context. If integration is attempted in an existing context without attention to the process and to the goals and capabilities of those involved, including their differences, the implications can be problematic, even harmful (at least in some respects, for some parties and over some period).

This means that sensitivity to the variations in convergence, including its interaction with diversity and the interaction of change and continuity is an essential ingredient. Such sensitivity calls for meta-level KB between these and related sectors, in addition to more specific KB within them. Methodologically, our analyses show the importance of heuristic and participatory approaches to explicating different interpretations and to dealing with disagreements about knowledge, values and premises for actions.

The challenges posed by the horizontal relationships between societal sectors take on new aspects. It is not only a question about coordination of administration, as broader actor networks become more directly involved, and as the transfer of evidence and other types of knowledge need to be embedded in collective processes of communication and evaluation. This research centered on models of KB need to be complemented by joint fact finding and other such new processes, introducing new problems, challenges and solutions.

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