This is an Accepted Manuscript of a book chapter published by Routledge in *The Water-Food-Energy Nexus* on 24 April 2019, available online: https://www.routledge.com/The-WaterFoodEnergy-Nexus-Power-Politics-and-Justice/Allouche-Middleton-Gyawali/p/book/9780415332835

Chapter 4 - The Knowledge Nexus and Transdisciplinarity

4.1. Why Nexused Interdisciplinarity?

Recent decades have witnessed the emergence of various movements concentrating on interconnections among nature, society and technology – and the disciplines that deal with them – whether under the broad title of environmental science, or more specific intellectual traditions like transition theory (Geels, 2002; Loorbach, Frantzeskaki & Avelino, 2017; Schwanen 2018). This compulsion is even more prevalent among resource managers who have to balance competing claims for contradictory ends. Water managers, for instance, have long wrestled with the uncomfortable fact that water is not so much a subject of study or praxis but more realistically a focal point where just about every subject taught in a university's different departments intersect: from atmospheric physics to hydrogeology, from civil engineering to economics, law, sociology, politics, ethics and even literature (Gyawali 2010). How to solve a water problem facing a business, community or municipality without running into opposition from competing claimants or disciplines has been a vexing and perennial problem. Efforts to address this difficulty is what led to the emergence of the movement for Integrated Water Resources Management (IWRM), itself a successor to the earlier approach which was the hydrology-inspired river basin management of the 1960s (Chapter 3). Allan (2003) has argued that IWRM too is failing since its votaries are not recognizing that it is broader than water and environment, that both integration and management are political processes which requires greater disciplinary ecumenism than practiced currently.

The nexus represents the latest in this evolving series of paradigms, described as a multi-dimensional means of scientific enquiry which seeks to describe the complex and non-linear interactions between water, energy, food, with the climate, and further understand wider implications for society. The shift to a nexus approach also parallels the shift from the much narrower Millennium Development Goals (MDGs) to the current Sustainable Development Goals (SDGs) since 2015, which are seen as more comprehensive and addressing concerns such as energy and equity missed by the MDGs. However, this encompassing of broader concerns brings with it significant conceptual, methodological and practical issues: how comprehensive can one be without losing analytical rigour; what tools need to be used; and what are the practical consequences? In addressing these conundrums, nexus is emerging as the epicentre, or meeting point of a series of (often complex) components, which come together to represent something that is more than the sum of its parts. As a result, interdisciplinary debates on the nexus focus on: (i) what it is that is 'connected'; (ii) the exact nature of those connections; and (iii) boundary issues, i.e. if everything is linked in some way, then when and where do we draw the line? (Howarth & Monasterolo, 2017)

Thus far, however, specific methods to address complex resource interactions with development challenges remain limited. There are of course specific data issues which makes nexus research more difficult, in particular the lack of data and limited data interoperability (on lack of data, see Houghton-Carr and Matt, 2006; on limited data interoperability, see Mohtar& Lawford, 2016 & Eftelioglu et al., 2017). Lack of data, limited data interoperability and data incompatibility are a few of the many data challenges hindering meaningful integration of relevant nexus data. Integrative and interdisciplinary frameworks and models are needed to create compatible datasets, which will then be able to support decision-making, for example through interactive platforms and maps. The current available

methodologies present many issues. A systematic review of 245 journal articles and book chapters reveals that (a) use of specific and reproducible methods for nexus assessment is uncommon (less than one-third); (b) nexus methods frequently fall short of capturing interactions among water, energy, and food—the very linkages they conceptually purport to address; (c) assessments strongly favour quantitative approaches (nearly three-quarters); (d) use of social science methods is limited (approximately one-quarter); and (e) many nexus methods are confined to disciplinary silos—only about one-quarter combine methods from diverse disciplines and less than one-fifth utilize both quantitative and qualitative approaches (Albrecht,et al. 2018). Most methodological approaches on the nexus are biased towards quantitative methods (more than 70% of studies used primarily quantitative approaches), mostly life-cycle assessment, input-output analysis, trade-off analysis, foot printing, or integrated models with scenario analysis (Albrecht,et al. 2018). Therefore, nexus-specific methods that better represent cross-sectoral social, environmental, and technical challenges are needed, as discussed in this chapter.

Since 2011, one can witness a proliferation of research articles on the need for interdisciplinarity and transdisciplinarity about the nexus, reflecting a call for greater integration of research efforts and policy prescriptions across disciplines (Endo *et al.* 2015a; Stirling, 2015; Wichelns 2017). Many researchers and policy analysts would consider that interactions across disciplines and sectors generally are helpful and informative. However, this is not a one-way debate, many also suggest there are many instances in which problem solving even within a complex system requires sharp focus within a discipline and narrow, high-level expertise that comes with it (Jones, 2009; Kanakia, 2007). In such instances, problems are best solved, and certain problems of efficiency or equity are best handled within policies that are narrow and with less than complete discussions across sectors.

Nexus is not just a policy tool and function but also an approach that requires a transformation in the way disciplines and sectors are working. The knowledge nexus will require re-thinking interdisciplinarity. Different organizing styles – governments, markets or movements – have different institutional filters that allow some data in as information but filter out others as 'noise' (Gyawali, Allan *et al.* 2006). Understanding that dynamics is critical to the nexus approach where interdisciplinarity has to be re-thought in terms of whether only one hegemonic discipline 'feeds' the problem or is the feeding more plural. What is needed, is not only 'joined up thinking', but profoundly transformative change in infrastructures, organisations, behaviours, markets, governance practices and even cultures more widely. These are the challenges linked to what we have termed the knowledge nexus.

The knowledge nexus is about a transdisciplinary approach, aimed at opening up and broadening out analysis, and linking theory and method to practical solutions that address today's global sustainability challenges. We will go beyond multidisciplinarity (combining disciplines) and interdisciplinarity (joining disciplines), to a process of joint learning and co-production. This requires broad-based research (across disciplines and methods), and co-creation of solutions (across sectors and including citizens). Through enabling (rather than suppressing) scepticism and criticism, policies become more robust, responsible and accountable. Messy, bottom-up transdisciplinarity can yield unexpected insights and possibilities, through exposure to other kinds of tacit, non-specialist or general knowledge – held by local communities, businesses, social movements, or many different kinds of practitioners (Stirling 2015). Through facilitating more radical interactions between different styles of knowledge, potentially transformative solutions can be fostered.

4.2. Interdisciplinarity and transdisciplinarity

Foran (2015) has explained two broad disciplinary traditions within nexus research. The first might be summarised as the systems complexity of the nexus, more specifically the systematic connections

between domains (e.g. food production). Disciplines such as economics, hydrology, engineering life cycle analysis, scenario analysis, and systems analysis have been used to describe such connections (Newell *et al.* 2011; Bazilian *et al.* 2011; Hoff 2011; Hussey and Pittock 2012; Howells *et al.* 2013). Findings are conveyed in terms of efficiency, productivity, trade-offs, synergies, and co- benefits.

The second tradition is around critical social science of the nexus, with a focus on power relations and the historical, cultural and socio-political dimensions of these relationships. This topic raises questions such as: "[h]ow has the resource nexus in a particular place emerged, historically? Which social groups are enriched (impoverished) by a particular resource nexus? Who gains or losses from attempts to intervene in the nexus?" (Allouche *et al.* 2015; Foran and Manorom 2009; Friend *et al.* 2009; Molle *et al.* 2009; Barney 2012).

Table 4.1: Two approaches towards the resource nexus. (Foran 2015: 658)

Characteristic properties	Complex systems thinking	Critical social sciences
Focus	Cross-level, cross-domain impacts of particular actions	Historical determinants of vulnerability, insecurity, or poverty in specific places Winners and losers from particular actions
Key processes	Absolute limits (biophysical, social) Interactions between reinforcing (positive) and balancing (negative) feedback) Cross domain interactions Unintended consequences Learning	Capitalist accumulation Market imperative Dispossession Institutions Discursive power Differences and stratification (e.g. gender, caste, class)
Common sequence of analysis	(Macro - > Meso - > Macro	Micro - > Meso - > Macro
Specific techniques	Quantitative modelling Scenario analysis	Historical analysis Critical discourse analysis In-depth actor interviews Ethnography

A holistic understanding of complex phenomena such as the resource nexus requires some kind of interdisciplinary inquiry. Because the two approaches differ in focus, theoretical processes, typical sequence of analysis, and techniques, combining them is analytically intensive, and presents challenges of epistemology (Foran 2015). This is true of practitioners as well as theoreticians. Gyawali (1989), summarizing the experiences of a water engineer thrust into a policy environment, distinguishes a multidisciplinary approach from an interdisciplinary one. The former consists of interdepartmental commissions and task forces where experts from different disciplines are brought together and contribute to the analysis of that slice of the overall problem at hand which are amenable to the application of their disciplinary tools and that ignore other aspects that lie in the penumbra of

interlinkages. In this approach, the final synthesizing of the various disciplinary solutions is left to some harried politician-minister with little training for it.

In contrast, an interdisciplinary inquiry strives to use the concerns of other disciplines to re-structure the arguments of one's own discipline. A common example from the water sector is when engineers planning a dam have to re-examine their technically optimal design with considerations of economics (can it be paid for?) or sociology (will those to be relocated agree to be displaced or not or at what price, which may require changing the dam height?) or law (how many court cases will we have to face from angry activists?). Breaking a whole into disciplinary components is essential for analysis, which is the act of *describing* different facets of a complex problem: when one wishes to do something about such a vexing problem, i.e. prescribe a policy for action in *solving* the problem, one needs to synthesize the various knotty aspects of it. That summing up for action is the essence of interdisciplinarity, which at its core is also what political decision-making is all about. Such enlightened formula for the use of power, i.e. policy, is an area of academic enquiry that is still in its infancy since established universities and departments tend to reward disciplinary contributions rather than interdisciplinary ones.

However, most researchers argue that interdisciplinarity is not enough, and what is required for the nexus is transdisciplinarity. There are numerous definitions of transdisciplinarity and understandings of how this differs from multi- and interdisciplinarity. Barry, Born, and Weskalnys (2008: 28) view these as a spectrum from multidisciplinarity – cooperation of disciplines whose framings remain largely intact – to transdisciplinarity. The latter term captures a type of reflexive and integrative knowledge production that is oriented at application and addressing societal and environmental problems and involves non-academic stakeholders as active participants (Klenk & Meehan 2015; Osborne 2015). Transdisciplinary methods aim for broad participation and to incorporate knowledge from various sources, such as academic research, on-the-ground practitioner experience, and local knowledge (Mauser et al 2013). By participating in the research process, stakeholders help guide the research questions, and study design. Transdisciplinary approaches are used to identify inter-sectoral relationships, achieve more holistic assessments, and improve integration of policy among sectors (Endo et al 2015b). Transdisciplinarity relates scientific and societal problems and “produces new knowledge by integrating different scientific and extra-scientific insights; its aim is to contribute to both societal and scientific progress” (Jahn *et al.* 2012: 8).

Harris *et al.* (2014) defined the requirements of a transdisciplinary approach for nexus analysis according to a literature review on trans-disciplinary research. In particular, they identified the associated theoretical (framing problems), methodological (different conceptions of proof) and practical challenges (communication, collaboration and trust across groups of actors belonging to different disciplines) for nexus analysis. For academia, they found that a key challenge relates to the need to embrace multidimensional knowledge, and to adapt the method of interaction to account for transdisciplinary team members (e.g., defining a new language, negotiate, accept the different logics and values, redefine the power balances among disciplines and among scientists and lay practitioners).

Thoren (2015) discusses interdisciplinarity in the context of sustainability science, an emerging field aimed at challenges like global warming which hopes to lay the foundations for a form of science that serves society by solving 'real world problems' leading towards planetary sustainability. Its strategy is to draw on the resources of a wide range of disciplines, both of natural and social sciences; but the challenge before that task is that of integration and joint problem solving. According to Thoren (2015), interdisciplinarity is often used as an umbrella term capturing many types of relationships between disciplines; but they can be reduced to a trichotomy of multidisciplinarity, interdisciplinarity and transdisciplinarity. Multidisciplinarity is understood here as merely the juxtaposition of knowledge claims from different disciplines that is additive and not integrative. By contrast, interdisciplinarity is integrative and, drawing on Klein (2010), Thoren distils the process of integration to: borrowing of tools and methods; solving problems without necessarily achieving conceptual unification of knowledge;

increased consistency of subjects and methods nudging disciplines to a state of merger; and finally the emergence of hybrid disciplines at the fringes or interface of already existing ones such as social psychology. Finally, for Thoren, transdisciplinarity, a term that emerged at an OECD conference in 1970, is the final and deepest stage of interdisciplinary collaboration with complete coordination, a kind of overarching synthesis.

This kind of broad transdisciplinary synthesis is guided by two features. The first is integration of science with society including local knowledge and value systems to solve real world problems where uncertainties are high and the underlying values are being challenged, whilst solutions are urgent. The second is problem orientedness where problems to be solved originate in the real world and not in the highly idealized theoretical frameworks or sterile laboratories. It is here that Thoren (2015) brings out the idea of "problem feeding" that distinguishes transdisciplinarity from multidisciplinarity and interdisciplinarity and which involves problem sharing and problem transfer between disciplines. And it is with this idea of problem feeding that transdisciplinarity becomes germane to the nexus approach. As a concept, the nexus is supported by a rapidly growing evidence base and a community of practitioners and policy makers, providing a powerful but largely disconnected knowledge base to understand the relationships and trade-offs between the different sectors and disciplines characterising the nexus (Harris and Lyon 2014; Stirling 2015; Kurian *et al.* 2014; Azapagic 2015).

4.3. Further transdisciplinary work required

There is a normative danger to recognise when engaging with interdisciplinarity and transdisciplinarity. Thinking interconnections across domains or systems is difficult, the argument goes, because of the specialisation and fragmentation of science. Howarth and Monasterolo (2016) for instance argue that a nexus approach enables the capitalisation of knowledge and the sharing of skills and expertise to build innovative solutions to complex interlinked nexus challenges. Much of the literature promoting the water-energy-food nexus is somewhat dismissive of research or policy analysis conducted in "silos," in which scientists or public officials pursue narrowly focused inquiries, without sufficiently interacting with specialists across technical disciplines (Finley and Seiber 2014; Azapagic 2015; Leck *et al.* 2015; De Laurentiis *et al.* 2016; Sharmina *et al.* 2016). None of the authors expressing this perspective provides evidence of any harm that has arisen as a result of such analysis. Yet, the implication seems to be that a nexus approach is superior to conducting research and policy analysis within scientific disciplines (Wichelns 2017). Interdisciplinarity can be pursued for different reasons (Barry *et al.* 2008) but with transdisciplinarity the most common reason remains integration. This is underpinned by a presumption of superiority: knowledge production can be improved and made more effective and impactful in addressing societal problems if the inevitable partial and telescopic character of disciplinary perspectives and practices is overcome through some kind of fusion.

4.4. Interdisciplinarity and Transdisciplinarity as transformative?

The potential for interdisciplinarity and transdisciplinarity to deliver innovation in its widest sense is large. Innovative transdisciplinary approaches are being increasingly used to address important societal challenges (Bammer 2013) and facilitate and navigate the interrelationships and trade-offs between energy, food and water within the nexus in parallel to the varying and often conflicting needs of actors involved (Zhang and Vesselinov 2016; Polk 2015). However, there is always the danger that new research 'performed' under this nexus transdisciplinary movement is not innovative at all, and just repeats and reaffirms old established knowledge.

One such example is the case of Hindu Kush Himalayan ecosystem services in South Asia, which demonstrated that in order to sustain resilience of resources and food, water, and energy security in the region, cross-sectoral integration was needed, along with regional integration between upstream and downstream players, critical for ensuring food, water, and energy security (Rasul 2014). Another

example, is the context of sustainable consumption of food, water and energy, a practices approach would explore the social organisation of cooking, which, as an activity, consumes food, water and energy, and can complement more traditional approaches in sociology. Similarly exploring the full impacts of a complete food chain through life cycle thinking (Azapagic 2015) could increase understanding of the diverse mechanisms that could be used to reduce the impact of this sector on exacerbating nexus shocks such as climate change (Jeswani *et al.* 2015). The point is not to be critical about these research projects, as these conclusions are perfectly sensible. However, they reveal the danger that a reframing of the problem through the knowledge nexus and transdisciplinarity may not be as transformative without a higher level of integration establishing a common system of axioms for a set of disciplines.

4.5. Policy or Politics: The road to more policy toolkits?

The second danger of this call for a transdisciplinary approach is to render it technical. Policy rather than politics becomes the focus, and it becomes a research governance question from which implications for policy making are derived. It becomes narrowly framed as a way to consider complexities around the variety and forms of data used to inform nexus-related decision making (Gilbert and Bullock, 2014). A number of studies have focused on these policy question. Howarth and Monasterolo (2016: 17), for example, have developed a transdisciplinary approach to knowledge development through co-production on energy-water-food nexus decision-making in the UK. Co-production as a methodology provides a space to facilitate knowledge exchange and sharing of insights from a range of perspectives and expertise, acknowledging that all those who contribute to the process have something to offer. It enables an inclusive, self-reflective approach whilst embracing the challenges that the process faces – and acknowledging the opportunities this provides (Howarth & Monasterolo 2017). In their knowledge co-production approach, expertise was drawn upon from across disciplines and fields as represented by the diversity of individuals invited to take part in the workshops. The multidimensional methodological framework was designed to accounts for feedback loops and cascading effects, and sought to inform decision-making processes to build societal resilience to nexus shocks going beyond the sectorality of current research practice (Howarth & Monasterolo 2016).

Howarth and Monasterolo's (2016) analysis of workshop discussions identified four dominant themes that emerged as barriers to decision-making in the context of nexus shocks: communication and collaboration, decision making processes, social and cultural dimensions, and the nature of responses to nexus shocks. Communication and collaboration are seen as vital to ensure the most appropriate and robust evidence informs decision makers at all levels within the context of a nexus shock. For example, collaboration between actors across sectors can lead to clashes in languages and lexicons as well as skillsets and expertise further exacerbating barriers that may emerge in the communication process (Howarth & Monasterolo, 2016).

One important concern that was identified by the workshop participants was the potential tension between probabilities and levels of uncertainty and clear advice for decision makers. In terms of decision making processes, workshop participants highlighted the lack of clarity over who owns the problem or the decision. Conflicting timescales between research and policy combined with the social dimensions of decision making and the need for researchers to achieve consensus before they can contribute to decision making can exacerbate responses to shocks and cause existing decision-making processes to become redundant.

A second issue shared by workshop participants was the lack of learning systems in place, "to capture these lessons during and after the shock, how this could inform thinking in future shocks and how these lessons learnt could then be transferred and applied to other sectors and scales" (Howarth & Monasterolo 2016: 57). The third theme highlighted was the different cultures, behaviours, priorities and processes by different stakeholders across different sectors. Finally, in terms of response to shock, the

production of scientific evidence used to inform decision making is imprecise, fraught with uncertainties and constantly evolving. According to Howarth & Monasterolo (2016), the need to move from the current reactive to a proactive decision-making process emerges strongly, with a necessity to embrace a foreseeing attitude to future nexus shocks and understand the importance of local action for global impacts.

These four themes and their findings are interesting but reveals a particular framing of how transdiciplinarity is being conducted. It is about closing down policy options and reaching a consensus to support decision making. The danger is that nexus transdisciplinary research becomes stuck in producing 'tools', 'techniques' and 'frameworks' for policy making, as illustrated in the logic above and the table below. Here, academics and scientists offer putatively neutral, a-political information that will allow others – politicians, policy-makers, businesses – to make decisions that help to increase the efficiency of resource allocation. In the process, they may miss transforming the previously unsustainable politics into a new sustainable one (Scoones et al 2015).

Table 4.2: Perceived opportunities to increase resilience to nexus shocks. (Howarth & Monasterolo *2017: 107)*

Contextual factors that help mitigate nexus shocks and include the (i) importance of clarifying what we consider as a cost, differentiating between computable, perceived and opportunity costs, and between costs that could be afforded (financial) or not (human lives) in case of shocks; (ii) emergence of a strong internal leadership; (iii) increasing collaboration across stakeholders and sectors as well as transparency and information sharing; (iv) improving communication of evidence and impacts of shocks targeting the language to the specific audience.
Strategic thinking that builds on the understanding of the big picture of nexus shocks' complexity and consists of (i) having a context-specific plan B to react quickly to nexus shocks prioritizing interventions based on lessons learned from previous experiences; (ii) clear division or roles to allow clear identification of interlocutors and match policy response to shocks; (iii) decentralization of decision-making and shared responsibility to increase stakeholders' engagement and ownership of responses to shocks.
Collaboration and communication characterized by the importance of establishing knowledge-transfer partnerships to design and implement a robust and efficient response to shocks by better understanding the longer-term risks associated with nexus shocks and building nexus narratives and framing responses with a focus on opportunities and business solutions. Moreover, the creation of a common stakeholders' language and narrative around nexus shocks is important to coordinate responses.
Anticipating social responses, by blending insights from the multiple sectors involved in the response to nexus shocks thus complementing knowledge and providing a framework which considers the big picture, to better deal with the complexity of nexus shocks. In this regard, it is fundamental to increase the accountability of the decision-making process combining evidence and data from decision makers and narrowing the gap between short-term policy objectives and long-term frameworks of measures to manage nexus shocks.
Processes to shape the right governance structure to respond to nexus shocks with the following desirable characteristics (i) resilience and efficiency to enable flexible planning and procedures, (ii) complementary and flexible mechanisms and institutions able to operate swiftly when needed, and (iii) innovation to decentralise decision making to better manage tailored, case-by-case solutions to cope with nexus shocks.
The relevance of **proper timescales in decision making** emerged as a transversal opportunity in all the five themes.

While much nexus research aspires to be post-normal and transdisciplinary, a lot of work therefore remains within a conventional model for stakeholder interactions that seeks to separate facts from values. It also reveals the lack of interdisciplinary research with critical social sciences as discussed earlier. What is happening is that transdisciplinary policy and consensual-type research in relation to the nexus is become disciplined and self-regulated, where members share similar epistemic cultures and research fields with specific concerns, methods, vocabularies and institutions. In other words, a complex landscape of power relations and forces within academia affects nexus transdisciplinary research.

The following discourse analysis through a word cloud software of Howarth and Monasterolo's (2016) article shows the emerging consensual dominant vocabulary and lexicon.

Figure 4.1: Word Cloud, based on Howarth and Monasterolo *(2016)*

Actors, responses and decisions become the main underpinning beyond nexus transdisciplinary research. Current policy making debates and political imperatives around the nexus are challenging transdisciplinary research through pressures to claim a definitive basis for predictive explanation of causal dynamics at a sufficient level of confidence and precision to justify large business strategies, infrastructure investments and long-term policy commitments.

As suggested by Schwanen (2017), there is perhaps a need to slow down trans- and interdisciplinary reasoning and practices. Particular concepts, ideas, logics and methods should not be plugged as ready-mades; they will have to be adapted and hybridised to a greater or lesser degree and may even have to be dropped altogether. In line with Stenger (2011), transdisciplinary nexus research should aim to understand the world not as a messy realm of competing value systems from which research should abstract to arrive at transcendental and disinterested truths, but as an inevitable condition they have to appreciate and learn from. Research practices should offer spaces for friction by allowing competent colleagues and non-academics to object and induce other modes of thinking. Interdisciplinarity and transdisciplinarity are about experiencing and dealing with contact zones as "social spaces where cultures meet, clash, and grapple with each other, often in context of highly asymmetrical relations of power" (Pratt 1991: 34). Yet, if asymmetrical exchange of concepts, ideas and methods across disciplines, epistemic communities and research fields and fragmenting pluralism are seen as undesirable, then a slowing down of reasoning will be needed (Schwanen 2017).

One method of conceptualizing the inherently plural nature of social interactions is through the neo-Durkheimian Theory of Plural Rationalities (or as more popularly known as Cultural Theory, see Thompson, 2008; Verweij and Thompson, 2006 and Beck *et al.* 2018) This integrative social science argues that, with just two discriminators showing whether competition is fettered or unfettered and whether transactions are symmetrical or asymmetrical, there emerge four styles of organizing: the first three being active bureaucratic hierarchism of procedural rationality, market individualism of substantive rationality, activist egalitarianism of critical rationality and the fourth being voter and consumer fatalism based on passive coping rationality. Each of them upholds a different view of nature (nature robust within limits; nature robust; nature fragile and nature capricious) as well as different approach to risk (risk managing, risk taking, risk amplifying and risk coping respectively). Within this framing of social interactions (it is the first three active social styles of organizing that strategize and cognize, strive to disorganize the others, and seek to bring into its fold of sanctioned behaviour the passive voters and consumers), problem definition itself becomes plural and hence proposed solutions even more varied. Thus, transdisciplinarity would mean that all the voices be not only heard at the policy table – which should not be hegemonized by the state agencies or that of the market – but also responded to. This is what in essence is the purpose and meaning of "problem feeding" discussed above. It is not of much

use if different voices are heard but the others doing the hearing do not internalize those concerns and do not respond to them. This listening to other organizing styles, re-examining their concerns and responding with revised options is then what transdisciplinarity would mean.

Cultural Theory would also posit that such a "constructive engagement" between different styles of organizing is what would ultimately force a nexused understanding among them. Indeed, bureaucratic hierarchism would veer towards procedural solutions of laws and regulations, market individualism would prefer to listen to neo-liberal economics of efficiency and profit while activist egalitarianism would opt for critical social sciences that bring equity and justice to the forefront. All three would have their strengths and weaknesses, all three would have a grasp of some aspect of the complex socio-environmental reality but none of them would be wholly right either. If the engagement among them in the policy terrain in not one of hegemony but democratic listening and responding, then a better nexused common and integrated understanding would have been achieved.

So, it is important to recall that nexus-related challenges can be more about enabling empowering hopes for distributed social progress, than urgent, top-down assertions of catastrophic technical fears. Key progressive responses to global challenges in achieving equitable and sustainable provision of food, water and energy are not about ‘sound scientific’ research informing ‘evidence-based policy’ to enable ‘pro innovation’ strategies that roll out global programmes for ‘scaling up’ the diffusion of particular ‘technological solutions’. These familiar kinds of high level policy buzzword do not just present too simple a picture. They also inflect it in highly partisan political ways, of a kind that are arguably more aligned with sustaining existing structures of privilege than achieving real material progress in addressing nexus-related challenges. In short, they treat nexus-related progress as a matter primarily of elite experts successfully engaging with elite policy makers (Stirling 2015).

How to go beyond narrow risk-based methods of ‘sound scientific’ ‘evidence-based policy’ to more fully address conflicting values, uncertainty, ambiguity and outright ignorance? The nexus is characterised by high levels of interconnectivity and uncertainty (Howarth and Monasterolo, 2016). Nexus- related interactions involve many different kinds of processes and relations, typically changing in highly dynamic ways. This means that consequences of different conditions and interventions are typically nonlinear – not only unpredictable but often profoundly surprising in ways that defy conventional statistical forecasting, optimising calculations or aggregating models. The food, energy, water nexus is a dauntingly deep and pervasive constellation of interacting global, natural, social and technological systems. That any given methodology might confidently yield even a generally robust appreciative understanding of key drivers and patterns in any given context, would be misleading (Stirling, 2015). It is for this reason that Klenk and Meehan (2015) advocate a mode of transdisciplinary research on environmental issues that values difference and recognises that the construction of a knowledge nexus is unequal and power-laden.

So, what are the practical implications for concrete nexus-focused methods and methodologies of this more explicit and realistic recognition of the roles played by power asymmetries in scientific research and knowledge production more generally? Before considering more general cross-cutting challenges in nexus-related methods and capabilities, the main point here is one of radical diversity. It is not just robust decision making and democratic accountability that provide imperatives for seeking alternative practical methods for addressing nexus-related challenges. Scientific rigour also demands more open-ended forms of uncertainty heuristics, interval analysis, sensitivity testing, and scenario assessment—each requiring attention to the differing conditions that may frame the question at hand (Stirling 2015).

One way of summarising the methodological implications of uncertainty, ambiguity and ignorance, is that they establish the need to radically ‘broaden out’ and ‘open up’ the range and kinds of methods used to produce knowledges about food, energy and water nexus linkages and interventions. In other words, there is a premium on those particular tools, techniques, and frameworks, that are capable of

taking into account a wider range of interacting factors in nexus-related challenges, scrutinise a more complete array of possible policy interventions, and engage with a greater diversity of ways of understanding these. In order to provide a basis for decision making that is as robust as possible, this evidence and analysis should be communicated with policy debates and wider political arenas in ways that are as systematic, clear and transparent as possible about contestable implications (Stirling 2015).

So crucial kinds of capacity-building for effective nexus-focused methodologies lie in nurturing capabilities that directly resist and counter any uneven balance of power. These include: egalitarianism, humility, pluralism and reflexivity on the part of all communities involved in nexus-related research and appraisal (Stirling 2015).

Egalitarianism means that practical implementation of nexus-related methods does not simply assume and apply the particular questions, framing assumptions, priority values or boundary conditions asserted by the loudest or highest status 'users'. Here (whether methods are interactive or analytic, quantitative or qualitative), training and skills for design and conduct of nexus-focused research and appraisal require capabilities to interrogate and more fairly counterbalance such bias and privilege.

Humility requires the building of capabilities among those institutions and disciplines benefiting from established structures of privilege in nexus-related appraisal, enabling them to be more deliberate in creating spaces for others – not denying contrasting understandings as 'irrationality', 'ignorance'' or 'jargon'. This means a readiness to be led where appropriate by agendas or questions set outside a particular home discipline or beyond academic disciplines entirely.

Pluralism requires an ethic of tolerance for interests, values or knowledges that are not only different, but directly contending with those of a particular individual, organisation or discipline. It means a capability to express and respond to scepticism, without interpreting this as existential denial. By encouraging (rather than suppressing) critical discourse, this helps foster more robust knowledge.

Finally, reflexivity is a quality whose very recognition requires all the above capabilities. It is the further more demanding capability to acknowledge how nexus-related challenges can look fundamentally different depending on the perspective from which they are viewed. This arises especially (though' not exclusively) from critical social science analysis, since this (by definition) involves interrogation and distancing from conventional interests and assumptions. But reflexivity is more a relational capability among interacting groups of perspectives, than a transcendent virtue located in any particular framework or individual.

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