

## Developing ‘Nexus Capabilities’: towards transdisciplinary methodologies

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Draft discussion paper (initially without references) for review at an ESRC Nexus Network workshop, to be held at the University of Sussex, 29-30<sup>th</sup> June 2015. Many ideas summarised here have been further developed and explored over the ten-year research programme of the [STEPS Centre](#).

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## **1: The Food, Water, Energy Nexus**

Pressures and tensions are high and growing around global provision of water, food and energy. Associated ecological, technological and geopolitical challenges are increasingly recognised to be profoundly interlinked. In order to understand the implications and strive towards progress in finding sustainable solutions, it is ever more clearly understood that circumscribed mono-disciplinary or single-sector approaches are not enough. 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 of 'the food, water and energy nexus' (or 'nexus').

Although contested in many details and settings, nexus-related challenges are some of the most serious and pressing imperatives in international politics. Focusing on several different visions of impending worldwide catastrophe, a profusion of large global assessments seeks to build a formally definitive scientific case for structuring 'evidence based policy' led mainly by elite actors in government, business and international organisations. There is an unprecedented drive for vertical forms of social change, driven by concentrated authority and top-down policies informed primarily by expert knowledge.

The sincerity of so many engaged in such processes is commendable – sometimes inspirational. The gravity and rapidity of stresses like those on climate, biodiversity and water use do certainly compel an acute sense of responsibility. Fears are indeed intense. Yet, often neglected, is that more familiar explicitly human-centred needs, entitlements and hopes are also profound. In parallel with emergence of nexus-related policy initiatives, high-profile international political developments are also unfolding, like progress towards Sustainable Development Goals. These global commitments are also [ambitiously transformative](#). And, albeit neglected, diverse social, political and technological innovations are already readily available for making water, food and energy provision radically more equitable and sustainable. 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.

This is important, because history arguably teaches a significant lesson about the social conditions for progressive transformative change on the enormous scale (and often rapidity) currently aspired to around interlinked global institutions, practices, cultures and infrastructures in the water, food and energy nexus. Put simply, many of the great comparable progressive societal transformations of the past tended to follow a quite radically different pattern to the processes of change that are currently envisaged in policy making on 'the Nexus'. For instance, unfinished and faltering progressive moves away from slavery, serfdom, worker exploitation, colonialism, racism, sexism and homophobia were all massively ambitious socially-deliberate cultural-economic transformations of a depth and scale broadly comparable to the transitions presently envisaged in more technical practises around food, water and energy provision. All were driven mainly by bottom-up agonistic struggle. And at key historical inflection points, each of these long-run secular processes has proven to be very rapid in its key formative stages.

What is striking about these ongoing historic transformations, then, is that they do not primarily follow a 'vertical' model of expert-driven analysis highlighting catastrophic fears, informing 'evidence based policy', implemented by orderly top-down procedures. Instead, the key driving dynamics have typically taken more horizontally distributed forms, with hope-inspired collective action, social mobilisation and democratic struggle often playing more dominant roles. It is within such broad social and political contexts, that expert debates over relatively narrow technical infrastructure changes are shaped and oriented. If anything, then, it is more bottom-up action that shapes top-down knowledge than the other way around. In short, although these two kinds of change process are strongly interlinked, it is clear that the great progressive transformations of the past were at least as much about horizontal politics as vertical policy.

Crucial to grasp, then, are the often-understated social dimensions of nexus-related challenges. Even in situations apparently relatively insulated from unfolding environmental and demographic changes, massive global inequalities persist in access to food, water and energy services. In the experience of the majority of the world's people, the limited progress in meeting basic food, water and energy needs are not prospective, environmental and technological, but immediate, economic and social.

So it is highly relevant that key historic barriers and opportunities in alleviating poverty and inequality around secure access to food, water and energy, have also been more institutional, financial and cultural than about science or technology alone. Whether retrospectively or prospectively, then, addressing nexus-related challenges is (despite the polite policy etiquettes) inherently strongly political.

## **2: The Politics of Nexus-Related Research**

The most crucial feature of emerging understandings of Nexus challenges, then, is that they are not just scientific and technological. The range of possible societal responses compounds the technical uncertainties, ambiguities and contestabilities. But dilemmas of choice are not where Nexus politics ends. It is not just the social and institutional contexts and alternative possible actions and policies that are inherently political. The ways in which the problems and possibilities are understood and appreciated can also be profoundly value-laden and pervaded by sectoral interests. So, entrenched power relations are not just obstacles to the material achievement of transformative change. They can also leave strong imprints in shaping policy knowledges about what these changes might even be.

For instance, a framing of ‘the Nexus’ as if it were a single discrete self-evident problem susceptible to primarily science-based solutions, is itself a clear indication of essentially political values. Ideas that there exist single technological ‘solutions’ to such massive, complex, pervasive and intensely-interlinked societal challenges, are highly instrumental simplifications. It is understandable that such expedient views might be propounded by partisan vested interests around particular disciplines or technologies. Where honestly recognised for what they are, such enthusiasms can be legitimate and energetic drivers in wider critical debates. But it is crucial to the realism and efficacy of deeper nexus-related understandings, that policy making is not allowed to be entirely shaped by these kinds of expediency.

Likewise, it is understandable in complex, hotly contested policy arenas, that beleaguered decision makers in government, business or civil society, seek to secure justification for particular decisions. Political pressures are acute to foster trust, command authority, secure acceptance and manage blame. Decision environments are not easy – and penalties for failure intense. So, resulting power dynamics typically seek strongly to understate complexity, neglect uncertainty, deny ambiguity and suppress dissent. In nexus-related research, for instance, these pressures can coerce analysts into prioritising the most vocal ‘users’, rather than fairly addressing a wider diversity of stakeholder and citizen interests. Most often asserted in this regard, are the agendas, framings and preferences of powerful business and policy actors. These are of course entirely legitimate – all the more so where seeking honestly to engage with formidable nexus-related problems. But they may sometimes differ quite strongly from the interests of marginal and vulnerable people, who often stand to be most directly affected.

The crucial point is, that these ‘real world’ political pressures bearing on production of knowledge about nexus interactions, do nothing to change the hard actualities of the ‘real real world’ of nexus-related challenges themselves. Implacably unmoved by political expediencies to simplify knowledge, assert particular agendas and claim straightforward operational ‘solutions’, interactions between water, energy and food infrastructures, institutions and resources themselves remain as complex and intractable as ever. Rather than denying these uncomfortable realities for their inconvenience to short-term political interests, then, the practical, democratic and scientific responsibilities are to recognise and explore them. This is the key task of methods for understanding nexus-related challenges.

### **3: Origins, Aims and Questions**

It is the above challenges that press most strongly on the present initiative of the [Nexus Network](#) of the UK Economic and Social Research Council, around which this draft working paper seeks initially to help facilitate and catalyse discussion. As invited by the ESRC to inform their Training and Skills Committee and doctoral training programme, the central aim is to inform development of enhanced methodologies for improving cross-disciplinary research on the global food, water and energy nexus. Identification, exploration and specification of the associated capabilities are especially salient in provision for doctoral training. But the implications are also important for wider cross Research Council collaborative research – and, indeed, provision for policy-relevant analysis more generally.

To this end, this present paper reports initial findings arising in considering more than a hundred different methods variously considered to be relevant to research and appraisal of nexus-related challenges. The methods surveyed encompass a diversity of disciplinary approaches, spanning many different natural and social sciences (including economics), and extending across engineering, medicine and many other professions, as well as humanities and the performing arts.

Organised in a way that will be explained, an indicative array of these methods is shown in Figure 6 below. This illustrates how the methods informing the present discussion span a series of formidable academic and institutional fault lines – including both analytic and interactive kinds of disciplinary practice, quantitative as well as qualitative epistemic cultures and deductive, inductive and abductive processes of reasoning.

Although methodological vocabularies and taxonomies are themselves often a major point at issue, the methods surveyed for this paper and schematically mapped in Figure 6 can be grouped into a wide variety of different types. In the terminologies used there, they include: empirical quantification, quantitative assessment and other evaluative techniques; grounded methods, interpretive analysis and other qualitative apprehension; and appreciative approaches, mixed theory and hybrid appraisal.

The key point is, that each of these contrasting approaches is well established in different areas of academic research seeking to inform decision making on nexus-related challenges. Many are strongly advocated – sometimes in quite partisan ways – by particular communities of researchers and practitioners. Yet both these and many other less broad-brush distinctions between contrasting methods, can deliver radically divergent pictures of nexus interactions or interventions in any given context. So if inadvertent bias is to be avoided, it is important to maintain a general level of balance.

However, such generality can also be a problem. In order for the discussion not to become unwieldy, the main aim of this exercise is to highlight key practical opportunities and threats relevant to design of provision for developing what the ESRC has called 'Nexus capabilities'. So, an additional strand in this work, including after the present analysis, will be a series of parallel ESRC Nexus Network activities. Among these current and pending initiatives are a series of thematic conferences looking at specific empirical settings in which water, food and energy challenges interact. These include a dedicated workshop looking at environmental values and successive workshops examining business strategies, and issues of resource equity, ecological limits, urbanisation and transformative innovation. It is in these kinds of concrete settings that the methodological issues reviewed in this paper will play out. How the issues look – and what might be concluded for policy and politics – will typically depend strongly on the details in each contrasting thematic sectoral, cultural or geopolitical setting

So the purpose of the present initiative is not to second guess these more focused and empirically grounded discussions. Each will hold its own particular implications for thinking and action around nexus-related methodologies. The specific aim of this present paper – and of the workshop at which it will be considered alongside other inputs – is not to give particular prescriptive practical examples. These can be explored in onward work. The task is rather to question and define some of the broader and deeper cross-cutting issues, challenges and possibilities, under which prescriptive examples might be tested. With these correspondingly clarified, other Nexus Network initiatives can address in more detail, how these general issues, challenges and possibilities might play out in particular contexts.

With such a complex focus, wide canvas and deep questions, there are dangers of bewilderment and paralysis. But to seek to avoid or suppress any of these complexities, would risk even more damaging denial of the realities. Simplicity may be expedient in courting temporary political advantage. But it is not rigorous, nor a good basis for practical success in policy – or wider social – action. So, the task instead is to seek pragmatic responses to the most intractable challenges. Only by balancing some academic tendencies to critical complexification and political pressures for expedient simplification, can justice be done to the gravity of nexus-related challenges.

So, key queries for this paper therefore address the most fundamental challenges in developing nexus-related capabilities. As we have seen, these go beyond immediate policy pressures, to wrestle with deeper political dynamics – including within research itself. This requires not only asking hard questions about how to be ‘practical’, ‘effective’ or ‘successful’, but what these qualities even mean and to whom. The kinds of political actions in focus are not just those suiting the most vocal, privileged or powerful ‘users’ of research, but also those that best enable the most marginalised and vulnerable people.

Then further detailed questions need to be asked about some of the foundational building blocks in seeking to enhance capabilities for nexus-focused research. For instance, what are the relevant methods, methodologies and capacities – and their links and tensions? What are the practical implications of contrasting notions of multidisciplinary, interdisciplinary and transdisciplinary? What exactly is the importance of context, complexity and subjectivity? How to go beyond narrow risk-based methods of ‘sound scientific’ ‘evidence based policy’ to more fully address uncertainty, ambiguity and ignorance?

Having opened these issues up, even more constructive queries arise over how to achieve greater practical reflection and reflexivity over contrasting nexus framings? What are the main synergies and complementarities between different kinds of operational method? How to broaden out the policy options, issues, understandings, perspectives and interests these methods address? What are the best ways for nexus-related methodologies to engage with wider policy debates in real-world political arenas?

These are the issues directly addressed in this paper, in order to inform development of methods, methodologies and capabilities for use in different settings. But taken together the overall aim is to clarify two quite immediate practical questions on which the first general workshop will focus:

***1. What kinds or mixes of method and methodology are needed to address nexus-related challenges?***

***2. What associated capabilities best inform and enable the necessary transformative action?***

#### **4: Multi-, Inter- and Transdisciplinarity**

In these general terms, then, what lies at stake are not just the levels of *capacity* to prioritise for contrasting disciplinary approaches and mixes in understanding the global food, water, energy nexus. Indeed, what might count as the relevant capacities themselves is far from self-evident. Frameworks, methods and tools cannot be assumed simply to divide up on a conventional disciplinary basis – or be prioritised individually according to established structures of academic privilege. Beyond quantitative capacities, it is the deep qualitative natures of constituting *capabilities* themselves that are at issue.

So, the character and scope of the nexus-related challenges reviewed here, mean that these capabilities should not be thought of in circumscribed *mono-disciplinary* ways. To do this, leaves understandings vulnerable to whatever happen to be the particular methods, values and interests contingently embodied in whatever disciplines are, in any given setting, the most high status or best-funded. For instance, it is inherent to the politics of research noted above, that those disciplines that tend to come most to the fore under these conditions are those that are most ready to perform confident forms of closure. To take one example, environment economics routinely offers apparently robustly quantified, authoritatively aggregated, precisely prescriptive conclusions of a kind required for policy justification. But, as we shall see below, the realities behind such expedient pictures can often be rather different.

Nor can the contexts and complexities of the food water energy nexus be fully addressed solely by hierarchical forms of *multi-disciplinarity*. This is about more effectively 'joining up' the contributions of different disciplines. Each discipline typically persists in its own ways of organising enquiry. Boundaries remain carefully negotiated. But serious efforts are made to bridge divides, illuminate interfaces and fill gaps. The ambition is to cover all the relevant ground, with each aspect addressed in a neatly differentiated fashion. Component parts are then added up to deliver an ostensibly definitive result. Complexity and criticism are met with increasing elaboration. The overall aim is to justify tricky political decisions, by asserting an unassailably prescriptive picture – backed up by the carefully marshalled authority of all the included disciplines.

Typically led by natural science, with social science just in instrumental support, multi-disciplinarity is the usual pattern of large scale international assessments. With rigidly organised formal structures confining each discipline in its own neatly-divided domain, the prominence of multi-disciplinarity in nexus-related policymaking is explicable more in terms of political pressures for closure, than any manifestly definitive status in the results. The main pressures are to deliver apparently simple and objective policy justifications, not to fully address the crucial nexus-related complexities and uncertainties. Of course, such initiatives can play significant roles, like catalysing onward critical debate. But with global stakes so high, it is precarious to give too much latitude to such political pressures in nexus-related research.

More explicit attention is therefore required to dynamics of interests and power in the ways nexus-related understandings are produced and structured, as well as implemented. As will be discussed in more detail, this means achieving more intimately and equitably *inter-disciplinary* engagements with 'the Nexus'. Unlike circumscribed mono-disciplinarity, or hierarchically-structured multi-disciplinarity, more diverse horizontal forms of inter-disciplinarity can enable greater flexibility and robustness in systematically exploring different ways of framing and interrogating the focal problems.

So, true interdisciplinary research strives to escape the shackles of particular theoretical prejudices, privileged methods or favourite solutions. To the extent this can be achieved, it is typically not through large integrated programmes, but more usually in more intimate pluralities embodied within small teams, or even individuals. Genuinely interdisciplinary researchers publish in or between several different fields, moving to and fro over time. The result is greater openness and transparency about the diversity of ways to understand and address particular problems.

Such plural forms of interdisciplinary research depend on particular conditions of enquiry. Through enabling (rather than suppressing) scepticism and criticism, policies become more robust, responsible and accountable. Apparently messy, bottom-up inter-disciplinarity can yield unexpected insights and possibilities, transcending neatly organised multi-disciplinarity. It facilitates more radical interactions between different

styles of knowledge, fostering potentially transformative solutions, and better linking scientific and technological advances with marginalised interests and social innovations.

However, although there is much "talking the talk" about inter-disciplinarity in nexus-related research, this doesn't always live up to its own claims. The intensity with which inter-disciplinary initiatives are proclaimed is not often matched by the hard realities of research organisation and incentives. The fact that powerful disciplinary interests are more challenged by inter-disciplinarity than multi-disciplinarity can make the former more vulnerable. And sponsoring political interests can find the resulting transparency about complexities and uncertainties highly inconvenient.

Beyond this, however, effective development of capabilities for understanding nexus-related challenges also means extending attention in **trans-disciplinary** ways beyond formally accredited academic disciplines and specialist agencies. Key insights are often provided by other kinds of tacit, nonspecialist or general knowledge – as often variously held by local communities, affected people, workers, small businesses, social movements, street level bureaucrats or many different kinds of practitioner.

Of course, whilst academic disciplines remain subject to their own particular political dynamics and institutional interactions and hierarchies, disparate knowledges and perspectives from outside academia bring their own structuring and limiting conditions. But the diversity in itself can also play essential roles in positively reframing and refocusing how nexus-related challenges are addressed. And more generalised non-specialist perspectives can often help avoid narrow disciplinary or institutional blinkers. Indeed, these kinds of knowledge can assist academic experts and government specialists better access their own common sense. It is in these and many other ways, that capabilities for various kinds of trans-disciplinarity can greatly improve the development of nexus-related understandings. Some of the particular issues involved in achieving trans-disciplinarity are returned to in more detail later after some further issues have been discussed (see Figure 13 below).

## **5: Methods, Methodologies and Functions**

Because less can be assumed about disciplinary norms, trans-disciplinary approaches to nexus-related challenges require especially careful attention to methods and methodologies. But before turning to the main points that arise from the hundred or so methods surveyed for this paper, it is necessary to give some attention to the complex ways in which different methods relate to the radically contrasting kinds of institutional and cultural context in which knowledges about nexus-related challenges are produced. Associations between particular features of methods and their associated institutional contexts can be quite 'thick' (in the sense that attachments and dependencies are deep). So, they can also be 'sticky', in that it can be difficult to transfer a specific methodological feature from one context to another.

In order to clarify later discussion, then, the range of terms used in this paper might usefully be distinguished at this point. In fact, many different vocabularies can be used to describe the same categories of process and issue. But the purpose here is simply to illuminate the scope. So, the point of outlining these concepts now is not to insist on specific words, but the distinctions to which they refer.

First, a 'method' is a codified way deliberately to produce knowledge about a focus of interest. Where the focus is on comparative, evaluative or appreciative understanding of interactions between water, food and energy systems and interventions, then this might be called a 'nexus-related method'. Like any method, this is only achievable by a range of associated – typically less visible and more material – 'practices'. No method can be fully understood without considering the associated practices.

In order to be able properly to implement any given method in practice, it is necessary to hold some very particular 'capabilities'. The degree to which any given capability is held, is a 'capacity'. In these terms, a 'methodology', is a particular way systematically to inform the pros and cons around how different methods (and associated capabilities) are applicable under contrasting circumstances. One aspect of these circumstances, is the institutional 'setting' within which a method is implemented.

In the case of nexus-related methods, key settings may involve radically different kinds of organisations, procedures, stakeholders, power relations, purposes or wider political-cultural contexts. Simply to illustrate this diversity, examples might include international assessments, government enquiries, regulatory committees, commercial strategies, legal procedures, formal negotiations, participatory processes, consultancy exercises, academic research, NGO studies and social movement activities.

Across these and other settings, there exist many contrasting kinds of methodological function. In the broadest of terms, there are different kinds of 'framework' under which nexus-related methods are applied. Frameworks provide overall orientation to the general kinds of question that are posed, assumptions that are made and foci that are adopted. Depending on dominant purposes in any given setting, for instance, include a 'technology assessment' framework. Here, the priority is to understand alternative innovation trajectories. Likewise, a 'life cycle analysis' framework focuses on different kinds of flowing (and embodied) materials and energies. A 'decision theory' framework, by contrast, emphasises the dynamics over time in contrasting possible sequences of decisions and events. A 'transitions' framework explores how to achieve some large scale infrastructure change. And so on.

Within and beyond these kinds of overarching framework, nexus-related methods include many ways to build more particular aspects of understanding. For instance, under each of these frameworks, a host of what be called 'techniques' are available for formulating questions, characterising interactions, comparing effects, engaging perspectives, addressing uncertainties, or spanning time and space. Especially prominent in established approaches to nexus-related challenges in this regard are techniques like risk assessment, cost-benefit analysis, ecosystems service valuation, multicriteria analysis, social psychological elicitation, extractive social science, interpretive ethnography and historical research.

And finally for the present purpose of illustrating the diversity and complexity of the different aspects and implications of 'methods', there exist a host of more circumscribed tools. Dealing with more particular challenges, such tools can in principle be readily transferred (as 'plug and play') across otherwise quite different kinds of method. Examples include techniques for handling probabilities, taxonomies, text documents, scenarios, or interview, archive, internet or geographical data – or a host of more mathematical procedures like sensitivity analysis, time discounting, scoring and weighting.

All the different functions described above in different settings (eg: 'tools', 'techniques' and 'frameworks') are all variously relevant to the ways 'methods' fit together. And many other possible functions may be recognised in and among the more than one hundred methods surveyed here (see Figure 6 below). In different contexts, each method may address different functions, or a combination. So, the point here is not to assert a particular scheme of functions, but to underscore a crucial understanding. The challenge of nexus-related 'methodology' is not simply to fit different methods together horizontally like a jigsaw puzzle, nor just vertically in relation to their perceived logical relationships, nor simply processually in their sequencing over time. It involves all these kinds of functions and more.

Before considering more general cross-cutting challenges in nexus-related methods and capabilities, then, the main point here is one of radical diversity. The issues discussed in this paper will typically cross-cut these contrasting frameworks, settings, methods and tools in very different ways. So, great caution is required in seeking to draw any precise general conclusions. However, all ensuing discussion in this paper will in principle be generally applicable to the whole wide range of contexts outlined here.

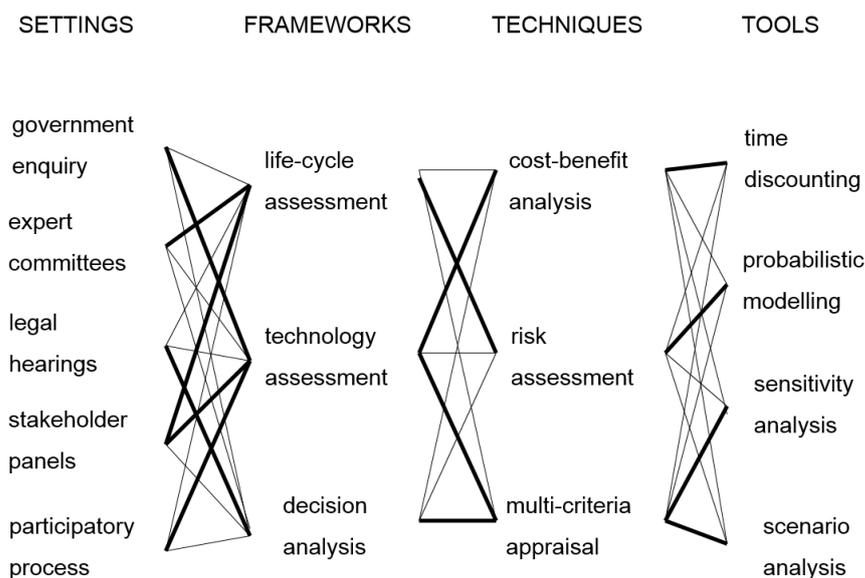
And there is one important further point to be made about the ways these different aspects of methods can and can't fit together. Despite the 'thick' and 'sticky' natures of many associations between methods and their institutional contexts (explained above), it is also the case that what are here referred to as tools, techniques, frameworks and settings may in principle all come together in a more radical diversity of different permutations than their normal conjunctions suggest.

For instance tools developed for use with one technique (like sensitivity analysis for multicriteria assessment; or discount rates for costbenefit analysis) may – under some views – be articulated (with appropriate adjustments) in entirely different ways. So, in principle, there is no technical reason why sensitivity analysis cannot be used in costbenefit analysis. But it virtually never is. The reason for this is not that it this is technically impossible (or even difficult). What prevents this combination is much more the

culture of costbenefit analysis. This holds such strong value-laden attachments to practices of reductive aggregation (as pressured by political justification), that practitioners are often averse to this particular combination. On the other hand, discount rates can in principle also be used in, say, life cycle assessment. But the sticky association with costbenefit analysis makes this very rare.

All this said, the task in hand in this present exercise is not simply concerned with the technical design, selection or justification of particular research tools or methods for investigating nexus interactions. Nor is it the aim even fully to describe the range of wider frameworks or settings which give such tools meaning and purpose and within which they are applied. To do this comprehensively would be a formidable – and highly contentious! – task. The goal is instead to seek to inform more informed, reflective and reflexive (as explained below) discussion and design over nexus-related methodologies and associated capabilities. And the issues summarised above and in Figure 1 mean that the issues at stake are not just highly technical, but also about the disciplinary and wider **politics** of contending possible ways in which any of the methodological dimensions dimensions and aspects discussed here can be appreciated and implemented in practice in radically different – but equally legitimate – ways.

**Figure 1:** a highly selective schematic illustration of some diverse methodological functions, illustrating the typically multiple permutations with which elements can in pinciple fit together, but with thick lines showing specific ‘sticky’ associations favoured by disciplinary cultures and practices



So, what is in focus in considering this broader question over ‘nexus-related methodologies’, are not just the pros or cons of various individual frameworks, methods and tools in diverse particular settings. Also key to methodology, are questions are about how different constellations of all these methodological dimensions can relate together across contrasting contexts and perspectives. How then, can ‘wholes be more than sums of parts’? In short repertoires of complementary nexus-related methods can together offer much greater scope, depth, fidelity, plurality and triangulation than any individual method alone. Nor should this wider task necessarily be seen as one of developing some single, notionally definitive, ‘Nexus Methodology’. The inherently political dimensions of all forms of knowledge about the food, water, energy nexus reviewed above, mean that any one methodology for thinking about methods can only be interpreted or evaluated in relation to wider associated **practices** and **cultures** within it is ‘thickly’ and ‘stickily’ set. As with divergent framings of nexus-related systems shown in Figure 4, then, so are there different framings of nexus-related methodologies. These are as important for the questions they ask, as the answers they give.

As in other areas of knowledge production, then, what counts as a ‘good’ or ‘bad’ methodology will depend partly on the interests in play. This is arguably true, for instance, of the political pressures for simplification

and reduction discussed above. Where the aim is instrumentally to support incumbent interests or advocate some other partisan position, a nexus-related methodology might be expected to emphasise methods that engineer some degree of artificial closure. Where positions are independent of instrumental pressures for closure, then nexus-focused methodologies may be correspondingly more open to illuminating an open plurality of understandings of nexus-related challenges.

As a result, questions for nexus-focused methodologies may go beyond simply finding self-evidently 'useful' means to some presumptively singular preordained 'end' like 'the public good'. Where some particular end is robustly and accountably justified (rather than simply being assumed), then this simply being 'useful' can be a legitimate task for a particular method. But thinking in wider terms of methodologies, also requires interrogating the contending possible ends themselves. This in turn means questioning what might be meant by 'useful' ... or 'users' ... or even 'success' in nexus-focused research. It is these kinds of vital methodological query that can open up 'devils in details' in understanding and practice. Without such critical methodological discourse, the knowledges produced concerning nexus-related challenges are likely to be brittle – and the associated policies seriously vulnerable to error and wishful thinking.

## 6: Context, Complexity and Uncertainty

One key point that's often made about nexus-related challenges, is that context matters. The precise ways in which water, food and energy imperatives interact, typically depend crucially on their ecological, geographical, cultural and political contexts. Also significant in shaping the resulting pictures, are the levels and scales at which it is envisaged that challenges be addressed. But context goes beyond issues of situation or scale. Especially important in shaping understandings of nexus-related challenges and their possible responses, are the social perspectives in which these are viewed. Despite the usual prefix 'the', there's not one "Nexus", but many nexus. And this is so even at the most carefully-defined of levels or scales of analysis, or in the most particular of localised places or spaces.

Other general issues manifest in every scale, level, place or space, are complexity and uncertainty. 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. Patterns can be 'fractal' – displaying similar orders at different levels, but with tiny differences potentially magnifying to enormous significance. Mathematically predictive causal explanations are routinely intractable. So, even for the most self-assured of disciplines, serious 'epistemological' questions arise, about how (even in principle) to understand nexus-related interactions, with what confidence and in what senses?

And beyond these queries, there loom even deeper 'ontological' questions. What kinds of categories and structures of concepts and relation should be used to build any given understanding of nexus-related challenges? How do these patterns in knowledge map onto patterns in the focal phenomena? How might pictures differ depending on how key categories are constituted or divided up? Such questions may seem a little philosophical. But they are of immediate practical importance in deciding how to 'join up thinking' from contrasting disciplines and sub-disciplines. Even different studies within a narrow peer-reviewed policy literature can display divergences yielding enormous variabilities.

An example of how important these kinds of problem can be, can be found even within a single relatively narrow field, let alone in the broader context of this nexus of different fields. To illustrate this, Figure 2 illustrates an example from a field where the use of rigorous comparative assessment techniques are arguably at their most mature and sophisticated – in the appraisal of energy strategies. The challenge here concerns understandings of energy systems alone, without the additional complexity of considering cross-cutting water, food or wider environmental processes. Yet even in this relatively well understood case, the complexities and uncertainties are truly formidable.

**Figure 2:** Implications of Nexus-Related Complexity: hidden uncertainties in state-of-the-art assessment (an example from external cost analysis of alternative energy supply strategies)

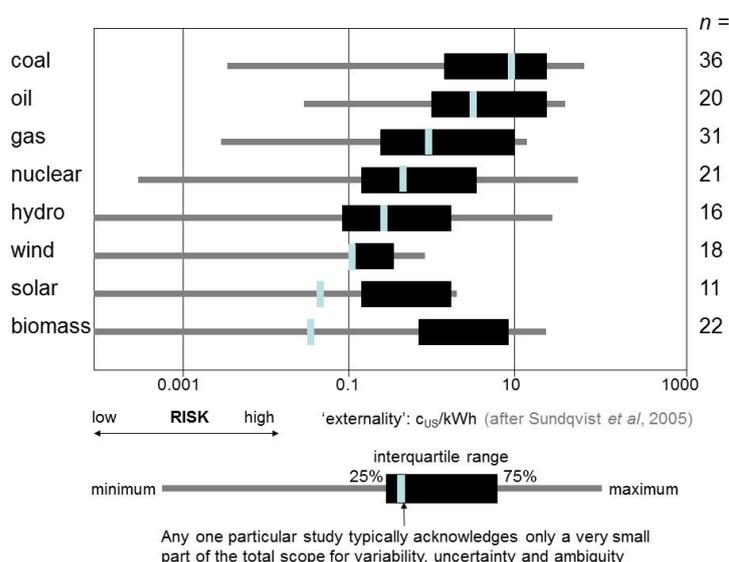


Figure 2 provides a graphic picture of the practical implications. It shows the results obtained by a series of 63 major international peer reviewed studies, seeking to answer the question '*what would be the best energy supply strategies?*'. The approach taken in this case is to quantify the many different kinds of benefit and impact using techniques of cost-benefit analysis. These arguably currently constitute the single most important and frequent kind of method in use – or advocated – for the appraisal of impacts of nexus-related interactions. For instance, the same basic procedures and issues arise in risk assessment, external cost evaluation and the valuation of ecosystem services.

The studies reviewed in Figure 2 are among the most authoritative assessments in this field, each being directly influential on policy making in some fashion. Different studies among those shown, examine contrasting permutations of eight key technologies (ie: coal, oil gas, nuclear, hydro, wind, solar and biomass). The number '*n*' on the right hand side shows the number of studies that assess each technology. The results are comparable in principle, because all the reviewed studies express their findings in the form of monetary values. So, the overall 'risk' associated with each energy technology is given as an 'externality' costed in US cents per kilowatt-hour of electricity production.

## **7: Risk, Evidence and Sound Science**

The crucial point to grasp from Figure 2, is the mismatch between the typically confident precision associated with individual policy studies of nexus-related issues and the massive degree of uncertainty across the literature as a whole. Published findings of a single indicative assessment are shown by the narrow pale-shaded intervals for each technology. Some results are represented not even as a range, but as single numerical values. And these are sometimes expressed with apparently exquisite precision – with values stated in up to four significant figures implying an accuracy of one part in ten thousand. Even the more cautious studies express their results with rather small ranges.

So, the impression given by this kind of body language, is that advanced quantitative assessment techniques like risk, cost benefit analysis or lifecycle assessment, are capable of providing a robust picture of the relative pros and cons of the alternative strategies in this field. For instance, the particular studies represented by the lightly shaded intervals in Figure 2, appear to suggest a clear ranking order running from relatively low risk biomass at bottom left, to relatively high risk coal at top right. This kind of prescriptive picture is the typical aspiration – and claim – in analysis of nexus-related challenges.

The problem with such interpretations according to single studies, only becomes visible when consideration is given to the ranges between the maximum and minimum values obtained across the multiple studies that constitute this peer reviewed literature as a whole. This full picture of variability, uncertainty and ambiguity is only rarely given in policy documentation – and virtually never properly acknowledged in the discussion of specific official reports. And the practical implications are even more serious, because different studies not only assign contrasting values to the risks of different technologies. They also tend to produce radically different ranking orders. And where studies seek to address the full scope of food, energy, water nexus interactions together, the greater expense can further diminish the chances of seeing the wider picture beyond a single study.

In other words, it is not only the absolute numbers that differ, but the relative orderings of technologies, policies or strategies from 'best' to 'worst'. Taking the entire evidence base summarised in Figure 2 into account, then, the uncomfortable implication is that this kind of 'sound scientific' assessment of alternative strategies and systems can yield pretty much any possible permutation of answers for policy making. Thus, the 'evidence based' implication for the appraisal of 'the Nexus' is, that there can on this basis be no single uniquely 'evidence based policy'. It implies no compromise on rigorous practice, to be able to base in this literature as a whole, pretty much any possible ranking order across key policy options.

The implications of this finding are profound. And this is all the more so, because other techniques than the monetary valuation methods reviewed here, also typically display at least the same levels of mismatch between explicit precision in individual appraisals and implicit inaccuracy across the field as a whole. For

instance, other methods showing the same kinds of discrepancies include technology assessment, life cycle analysis, decision theory and environmental impact assessment.

Nor is the basic pattern confined to energy, but is often even more evident across other less well addressed areas related to the food, water, energy nexus. Examples include appraisals of contending agricultural strategies, diverse water infrastructures and disparate ways to address these together and with energy. So, when ambitions extend to understanding the combined implications of strategies across energy, water and food taken as a whole, the challenges can only be expected to grow, rather than diminish.

### 8: Objectivity, Subjectivity and Framing

So, why is this? What are the causes of such enormous variability in the results obtained by different apparently equally-authoritative methods? Before attention can turn to methodological responses, it is necessary to understand better exactly how and why such problems emerge. In a nutshell, the answer is quite straightforward: answers depend on questions. All analysis must be framed in some way. Different framings produce contrasting results. Even when compliant with the same disciplinary standards, divergent studies typically frame a problem in subtly different ways. And the nonlinear effects of such fine-grain contrasts often mean that ‘the devil is in the detail’. So it is divergent but equally-valid framing assumptions that yield the enormous hidden variability, uncertainty and ambiguity illustrated in Figure 2. An illustrative example of the kinds of framing assumption that can have these kinds of effect in both quantitative and qualitative appraisal are summarised in Figure 3.

**Figure 3: Factors Influencing Framings of Understandings of Nexus-Related Interactions**

<b>Equally relevant to quantitative and qualitative approaches</b>		
setting of agendas	defining problems	posing of questions
prioritising of issues	deciding on context	choice of methods
power relations within process	definition of options	selection of alternatives
treatment of dissensus	design of process	drawing boundaries
<b>More relevant to expert and quantitative approaches</b>		
discounting of time	formulating criteria	characterising metrics
setting of baselines	basis for probabilities	including disciplines
handling of uncertainties	recruiting of expertise	commissioning research
constituting proof	exploring of sensitivities	interpreting results
<b>More relevant to participatory and discursive approaches</b>		
identification of stakeholders	phrasing of questions	bounding of remits
recruitment of participants	provision of information	choice of focus
personalities of protagonists	medium of discourse	style of facilitation
documentation of findings	dynamics of persuasion	adoption of norms

Detailed reasons for particular observed uncertainties or ambiguities are typically quite complicated. But the underlying issues are easily expressed. Any given nexus-related ‘problem’ or ‘solution’ is partly in the eye of the beholder. The challenges of understanding nexus-related interactions are not only about grasping the extraordinarily complex dynamics of large-scale interacting **objective** systems – like energy, water and food infrastructures (or the social, ecological and physical systems in which these are embedded). Although these challenges are formidable enough, what’s often even more serious are the complex dynamics in the **subjective** processes through which these systems are framed.

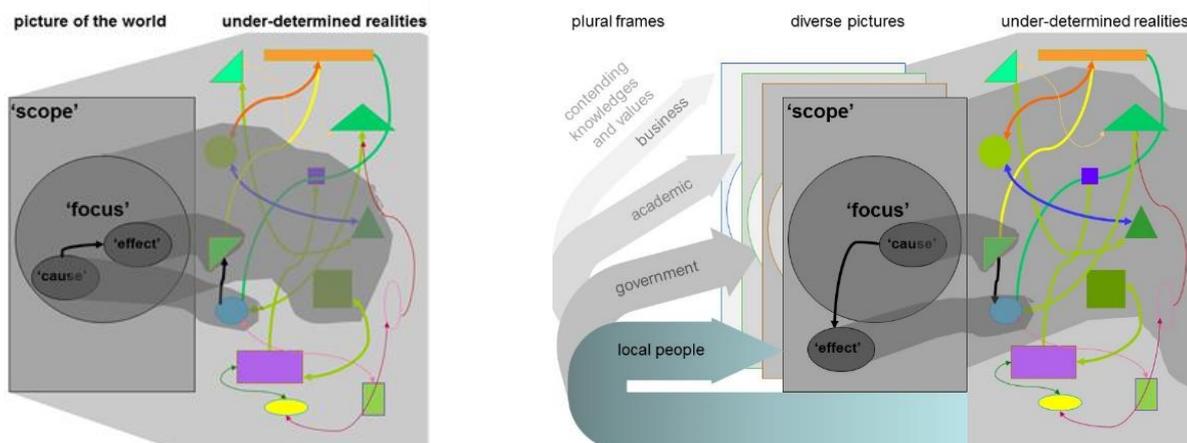
This point is illustrated in Figure 4. Figure 4(a) shows a particular picture of the world emerging from a specific framing. On the right hand sides of both 4(a) and 4(b) are suggested schematically, the complexities that underlie this – of multiple dynamically-interacting elements in strategies for food, water and energy provision in social, technological, ecological and wider physical systems. What Figure 4(b) shows, is that contrasting framing assumptions concerning the focal system or intervention and its situation in its environment can yield (sometimes quite radically) different understandings of specific relevant ‘causes’ and ‘effects’ within this complexity. These framings involve foregrounding particular aspects and backgrounding

others. For instance (as in Figure 3) this may involve different motivating questions, system boundaries, system definitions, taxonomies of components, models of relations and a host of other factors.

**Figure 4:** Framings of Complexity in Nexus Focused Research and Appraisal

**4(a)** a single 'objective' picture under a particular framing of 'the Nexus'

**4(b)** the overall subjective and intersubjective context for contrasting nexus-focused framings



The main point illustrated in Figure 4(b) is, when analysis is framed according to the perspectives of different social actors, a contrasting picture will be yielded of what counts as nexus-related dynamics. For instance, different groups of local people, government agencies, commercial firms or academic disciplines may all display quite radically contrasting perspectives. Analysis may be conducted equally rigorously in relation to any of these (and other) kinds of plural framings. And this is what generates variability within the peer reviewed 'evidence based' literature illustrated in Figure 2.

Crucially, none of this requires a relativist position as to the existence of an underlying 'objective reality' that constitutes nexus-related interactions in all their complexities. The picture in Figure 4 is simply being as practical and realist about process of knowledge production as about the processes on which these focus. More is said on this below. For now, the key point is, that no given understanding of nexus-related realities is fully determined by the objective conditions. Understandings are also 'coproduced' by subjective contexts of the processes of understanding themselves.

In other words, the pictures typically produced in any analysis of nexus-related realities are under-determined by the objective conditions. They also depend on the particularities of the framings through which nexus-related processes are apprehended. So what matters in any given view of 'the Nexus' and its policy implications, is not simply the objective characteristics of the strategic, institutional or technological options for water, energy or food provision, or of their wider ecological or physical environments. What matters most, is the larger context including these objective characteristics as well as the subjective conditions in which relevant nexus-focused knowledge has been produced. To ignore this simply because it is challenging or inexpedient would, again, yield a grave vulnerability to error.

## **9: Critical Reflection and Reflexivity**

So, any real understanding of 'the Nexus' in any given policy setting, must include attention to both the subjective and objective conditions of knowledge. This involves coming 'out of the page' of a conventional scientific assessment of the kind illustrated schematically in Figure 4(a) and recognising the wider context shown in Figure 4(b). Without this, policy understandings will remain vulnerable to the ways in which any

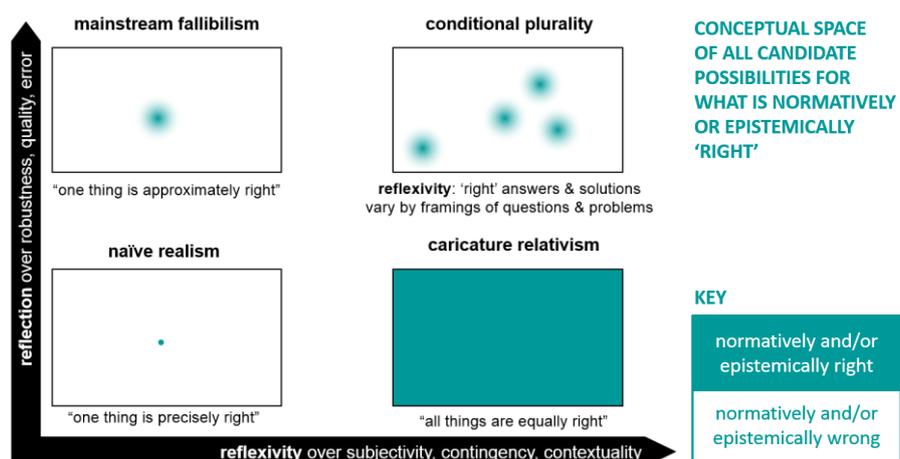
given perspective – like that of a particular study shown in light shading in Figure 2 – remains highly brittle in the face of the hidden variabilities, uncertainties and ambiguities. In short, practical methodological responses to dilemmas of framing, lie in crucial social qualities of “reflexivity”.

Much ink has been spilled over this simple observation. The message can be threatening to hardline emotive positions in favour of simply insisting on precise quantification, despite the complexities. Under such defensive views, the strategy is often just to dismiss ‘reflexivity’ as ‘social science jargon’. But the meaning is actually very straightforward. Reflexivity is – quite simply – the ability to reflect on how things look different, depending on how they are viewed. This is what is shown in Figure 2, reflecting factors listed in Figure 3 and the underlying reasons summarised in Figure 4. Only without this kind of reflexivity, is it possible to entertain the idea that there can be a single definitively ‘evidence based’ or uniquely ‘sound scientific’ policy in respect of any aspect of ‘the Nexus’.

As hinted at above, one common way to reject the practical reality of the need for reflexivity, is to caricature it as ‘anything goes’ relativism. This involves the simple confusion that just because more than one possible rigorous interpretation or recommendation of nexus-related interactions may be equally correct, it follows that there is an inability to recognise when other interpretations or recommendation are just plain wrong. This, of course, nonsense. Several contrasting understandings can be recognised to be equally true, without implying that all possible conceivable understandings are also equally true. After all, any three dimensional object will look radically different when viewed from different angles. And it is impossible to justify any single representation as definitive. But this does not mean that any conceivable misrepresentation of this object is therefore necessarily valid.

Figure 5 summarises how it is entirely possible at the same time to be critically reflective about the possibility of error in scientifically valid understanding of nexus-related dynamics, at the same time as socially reflexive about how any given picture of Nexus interactions will necessarily lie partly in the eye of the beholder. The horizontal axis shows capabilities to be reflexive over the importance of subjective views and contingent contexts. The vertical axis shows the propensity to be able to recognise robustness and quality in knowledge, as well as downright error. Between them, these dimensions define a space of all possibilities for what might considered epistemically ‘correct’ or normatively ‘right’ (ie: the right thing to do). Each of four idealised permutations of reflection and reflexivity in these terms, is labelled with a well-established term from the philosophy of science.

**Figure 5: Reflection and Reflexivity in Understanding Nexus-Related Interactions and Implications**



In the lower left hand corner of Figure 5, we find naively precise quantifications of relative risks, benefits, impacts or valuations associated with contrasting nexus-focused strategies. This corresponds with the fine-shaded intervals for typical individual studies shown in Figure 2. Such ‘naïve realism’ is neither reflective nor reflexive. In the upper left hand corner we find the more nuanced fallibilism of mainstream nexus-related

science. Reflective but not reflexive, this acknowledges that uncertainties mean that any given understanding of a nexus-related context can only ever be approximate. But it clings to the idea that there can somehow only ever be one valid way to frame this context.

The caricature accusation of relativism mentioned above is indicated in the lower right hand corner of Figure 5. A lack of reflection over error, implies all interpretations to be equally right. In the upper right corner, however, there is both reflection over error and reflexivity over divergent framings. This recognises that there exists a plurality of 'true' understandings of any given nexus-related challenge, and associated notions of the 'right' policy. Each is conditional on contrasting equally-valid framings. The challenge for nexus-related methodologies, then, is to respect imperatives both for reflection and reflexivity.

## **10: Inductive, Deductive and Abductive Methods in Nexus-Focused Research**

As has been emphasised, 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, can be a tricky aspiration to justify. But current policy making debates and political imperatives around nexus-related challenges are routinely imposing even greater ambitions. As we have also seen, the pressures are strong 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.

Whether the aim is substantively to address these challenges, or merely to provide instrumental justification, the basic problem is the same. Not only is there no single method that can bear this political load. No matter how high their policy status might be in other respects (like economics), there exists no single discipline that can do so either. Nor even is there any generally encompassing style of enquiry or 'epistemic culture' (like quantitative or qualitative analysis in general), that can solely shoulder the political burdens. No matter which view is taken on these challenges, what is clear is that what is needed is a general methodology under which can be harnessed a diverse mix of complementary methods.

These issues are too broad to detail fully in this present discussion paper. In principle, the repercussions extend across the full scope of epistemology and the philosophy of science. All that can be attempted here, is a sketch of some of the key general implications. For the purposes of the present discussion, this has been explored by reference to a survey of more than one hundred separate research methods variously implicated in the examination of nexus-related challenges. Of course, the fact that what counts as 'a method' (rather than a collection, or a variant) is itself highly ambiguous. Methods are vary on multiple dimensions. Each is a continuum, rather than discrete. Contrasting definitional schemes can yield a bewildering variety of nested and cross-cutting categories. So, the precise identities – or even number – of methods in question is not the point. For present purposes, what matters is the general point of profound disparity. This is shown in Figure 6.

In order to illuminate a number of key illustrative kinds of variability, Figure 6 distinguishes three principal general considerations in distinguishing between methods relevant to researching Nexus interactions. Each consideration is necessarily only approximate and indicative, suggesting many more detailed complications, context dependencies and exceptions. First, the twofold shading of a method's name in green or blue indicates whether the main social practices and relations involved in implementing it, tend to be (what might be called) 'analytic' or 'interactive' in nature. By 'analytic', what is referred to are relations and practices that typically involve a closed subset of actors of particular kinds, operating according to shared narrowly-defined activities, values and commitments. 'Interactive' methods, by contrast, involve practitioners engaging in implementing the method, with diverse kinds of social actor, in order to elicit implications of contrasting values and commitments.

Figure 6: Contrasting Practices, Cultures and Styles of Enquiry in Nexus-Related Methods

NEXUS METHODS			EPISTEMIC CULTURE			key: <i>analytic method / interactive method</i>			
primarily qualitative			explicitly mixed			mostly quantitative			
STYLE OF ENQUIRY	mainly inductive	<b>QUALITATIVE APPREHENSION</b> <i>do-it-yourself</i> <i>juries</i> <i>open space</i> <i>participatory theatre</i> <i>ethno-methodology</i>	<b>HYBRID APPRAISAL</b> <i>extended foresight</i> <i>alternatives assessment</i> <i>participatory rural appraisal</i> <i>technology assessment</i>	<i>natural experiment</i> <i>precautionary appraisal</i> <i>multicriteria mapping</i> <i>co-operative research</i>	<i>surveillance</i> <i>value chain analysis</i> <i>critical accounting</i> <i>citizen science</i>	<b>EMPIRICAL QUANTIFICATION</b> <i>longitudinal methods</i> <i>social indicators</i> <i>attitudinal scaling</i>	<i>data mining</i> <i>co-word analysis</i> <i>experimental economics</i> <i>econometrics</i> <i>scientometrics</i>	<i>monitoring</i> <i>remote sensing</i> <i>cladistic taxonomy</i> <i>statistical methods</i>	
		<i>social assessment</i> <i>historical method</i> <b>GROUNDED METHODS</b> <i>stakeholder negotiation</i> <i>multi-sited ethnography</i>	<i>power tools</i> <i>action research</i> <i>participatory backcasting</i> <i>semi-structured interviews</i> <i>innovation histories</i>	<i>concurrent evidence</i> <i>scenario workshops</i> <i>soft systems theory`</i> <i>resilience analysis</i> <i>cross-frame analysis</i>	<i>content analysis</i> <i>case studies</i> <i>Q method</i> <i>planning cells</i> <i>spatial analysis</i>	<i>futures visioning</i> <i>post-normal science</i> <i>deliberative polling</i> <i>critical triangulation</i>	<b>EVALUATIVE TECHNIQUES</b> <i>environmental assessment</i> <i>agent-based modelling</i>	<i>panel studies</i> <i>gaming techniques</i> <i>decision analysis</i> <i>meta analysis</i>	<i>Bayesian models</i> <i>social multicriteria analysis</i> <i>evaluation methods</i> <i>interactive visualisation</i>
		<i>photo-elicitation</i> <i>performative approaches</i> <i>arts catalyst</i> <i>situational activism</i> <b>INTERPRETIVE ANALYSIS</b>	<i>imaginaries analysis</i> <i>structured deliberation</i> <i>narrative analysis</i> <i>evidentiary presumptions</i> <i>critical pedagogy</i>	<i>discourse analysis</i> <i>situational analysis</i> <i>process tracing</i> <i>focus groups</i>	<i>constructive technology assessment</i> <i>counter-factuals</i> <i>systems histories`</i> <i>road-mapping</i>	<i>network analysis</i> <i>uncertainty analysis</i> <i>capabilities</i> <i>interactive diagrams</i> <i>study groups</i>	<b>MIXED THEORY</b>	<i>integrated assessment</i> <i>opinion surveys</i> <i>ecological footprint</i> <i>information theory</i>	<i>crowd sourcing</i> <i>interactive modelling</i> <i>contingent valuation</i> <i>life cycle approaches</i>
mainly deductive									

The second highlighted consideration in Figure 6, is the ‘epistemic culture’ mentioned above – distinguishing those kinds of method that might broadly be characterised as ‘mostly quantitative’, ‘primarily qualitative’ or ‘explicitly mixed’. Indicated in the three main columns in Figure 4, this raises many complications. One of these is that – despite vigorous protests to the contrary – it must be recognised that all quantitative methods are essentially also fundamentally qualitative at root. After all, it is the underlying qualitative category systems and relational structures that drive the resulting pictures. There is no quantitative method under which changes to the underlying qualitative constitution would not yield radically different results.

Nonetheless, it remains useful as a basis for one distinction between methods, to ask whether they routinely involve explicitly cardinal (absolute) or ordinal (relative) orderings. If they do, they are ‘mostly quantitative’ in these terms. Only if the method explicitly interrogates the qualitative basis for these orderings, might it be considered ‘explicitly mixed’ in terms illustrated in the central column in Figure 6. Otherwise, the method is indicated in the left hand column as ‘primarily qualitative’.

There is another key complication in contemplating the meaning of the term ‘quantitative’. The above definition makes no mention of the degree to which the cardinal or ordinal orderings developed by a given method are aggregated or not. Particular methods (for instance many kinds of decision analysis or physical modelling) may arrive in very precise ways at particular orderings in relation to specific criteria – and thus clearly be ‘mostly quantitative’ in these terms. But they may (like multicriteria mapping) sometimes nonetheless deliberately avoid aggregating these orderings into a single supposedly definitive final picture.

This is a crucial factor in the earlier discussion in this working paper – relating to the degree to which any given method is capable of acknowledging complexity, uncertainty and ambiguity. The fact that particular disciplinary cultures around specific quantitative methods (like cost-benefit analysis) display strong commitments to aggregation, does not mean that all quantitative methods should necessarily be considered aggregative. After all, many qualitative methods are also aggregative in important ways. For many

deliberative approaches involve an aggregative drive towards consensus conclusions or verdicts (like consensus conferences or citizen juries respectively) and many interpretive methods (like ethnography) also often involve the aggregation of a single narrative to represent a particular context. This is a point worth underscoring here, because it is a key issue returned to later in relation to the 'opening up' of contrasting framings of nexus-related interactions and the diverse implications of different interventions.

A third consideration in distinguishing different kinds of methods, is represented in the three broad rows in Figure 4. This concerns an apparently more philosophical point concerning the cognitive processes involved. But this can be a crucial issue in interpreting the practical policy implications of different methods. In short, do the principal processes of reasoning associated with a given method tend to be 'largely deductive', 'mainly inductive' or 'chiefly abductive' in nature? Whether quantitative or qualitative, interactive or analytic, processes that might broadly be referred to as 'largely deductive' are about the demonstration of conclusions from precepts. They will typically tend to justify hypotheses (and associated conclusions) by prominent reference to supposedly foundational or axiomatic properties of the disciplinary framework within which the method is set.

A 'mainly inductive' method, by contrast, is notionally more directly informed by the empirical evidence. Where a hypotheses is acknowledged, it is examined in the light of this information in order to arrive at conclusions. In this case, a method will typically tend to justify hypotheses (and conclusions) more prominently by reference to highlighted features of the empirical information under examination in any given application of that method. Finally, a 'chiefly abductive' method is about the creative exploration of alternative possible hypotheses. This will typically tend to justify a given hypothesis (and its implicated conclusions) mostly in relation to a number of other hypotheses that might also be defined under the conceptual framework or empirical information in play in any given instance.

There are very pragmatic reasons for distinguishing these properties of disciplinary practice (analytic or interactive), epistemic culture (quantitative or qualitative) and process of reasoning (deductive, inductive or abductive). In short, each can deliver radically divergent pictures of nexus-related interactions or interventions in any given context. If the outputs of a particular assessment of nexus-related challenges is not to be vulnerable to being seen as a trivial reproduction of the inputs, then the associated methodology will need to make systematic and deliberate efforts to address this.

Practical considerations in this regard might mean selecting a portfolio of contrasting methods, whose particular disparities can be seen as complementary in covering key inherent axes of diversity in a given nexus-related problem (eg: different aspects or settings or scales). Or they might mean sequencing a repertoire of synergistic methods, whose various characteristics interact in order to address each other's respective strengths and weaknesses over the course of a research process (eg: scoping out a problem, formulating questions, informing findings, drawing conclusions). Or these practical considerations might involve designing a research process in order that the contrasting pictures given by different methods of particular nexus-related phenomena are explicitly triangulated against each other. In this case, the explicit plurality of diverse pictures depend on carefully calibrated differences of perspective, each with their associated conditions. This offers a useful way to address the realities of nexus-related challenges illustrated in Figure 4 above.

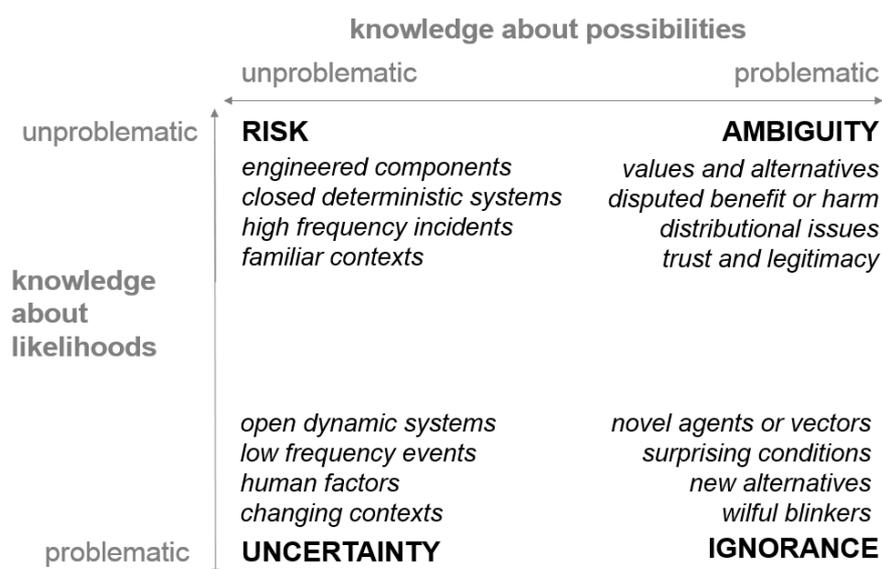
## **11: Uncertainty, Ambiguity and Ignorance**

The previous section made reference to a wide field of literature involving more than a hundred radically different methods spanning analytic or interactive practises), quantitative and qualitative epistemic cultures and deductive, inductive and abductive processes of reasoning. This illuminated key indicative general dimensions of diversity that might be useful under different perspectives and contexts in addressing nexus-related challenges. This in turn established the range of important kinds of methodological opportunity that arise for constituting portfolios and repertoires of methods for harnessing complementarities, synergies and potentials for triangulation.

In order to interrogate further and more specific issues in the design of nexus-related methodologies, a closer look might be taken at the crucial cross-cutting nexus-related challenges with which this paper began: complexity, uncertainty, ambiguity, contestability, indeterminacy and the political pressures for artificial closure. A comprehensive discussion of all these factors could easily become very lengthy and complicated. But one way to make the task more straightforward without undue simplification, is to view all these different dilemmas in terms of the different kinds of ways in which knowledge of nexus-related challenges can be variously seen as problematic.

Figure 7 offers a stylized picture of fundamental ways in which knowledge conditions bearing on nexus-related policy making may be seen as problematic. For ease of understanding, Figure 7 is structured according to the conventional parameters of expert risk regulation: probabilities and magnitudes. As explained earlier in discussing Figure 2, this is the most well established framework around the world, employed in the governance of food, energy and water infrastructures. It is this framework that usually underlies more widely contrasting approaches to analysing nexus-related challenges (like decision analysis, cost-benefit assessment, environmental evaluation, ecosystem service valuation, life cycle analysis and so on). In short, Figure 7 shows a range of different dilemmas that lie behind the enormous scope for variability shown in Figure 2, that typically pervade (whether acknowledged or not), the use all these kinds of method in nexus-related research and policy appraisal.

**Figure 7: Contrasting Aspects of Incertitude in Nexus Related Research and Appraisal**



The key point structuring Figure 7, is that understandings of nexus-related interactions can be problematic in quite distinct ways, equally in relation to deriving the probabilities (or likelihoods) associated with the different outcomes that might occur and in relation to divergent interpretations of each possible outcome itself. Each dimension presents a distinct way in which it is possible to be more or less confident in knowledge of nexus-related interactions. It is important to appreciate that this is not a taxonomy of conditions under which knowledge is objectively better or worse. The point is rather to reinforce that made earlier in relation to Figure 4: how a given body of nexus-related knowledge is framed, is crucially inherently subjective.

The top left quadrant in Figure 7 shows the classically emphasised condition of ‘risk’—where there is felt to be complete, high quality knowledge about both magnitudes of possible outcomes and their respective probabilities in any given framing of a nexus-related challenge. These are the conditions emphasised in conventional probabilistic approaches – and beyond which they are not properly applicable. Here, there is

confidence that dimensions held to characterise both likelihood and outcome can be fully quantified and multiplied to yield formal expressions of risk.

The lower left quadrant in Figure 7 indicates the crucially contrasting conditions of uncertainty. Despite varying usage in different literatures, the long-established strict definition of a state of uncertainty, is that it affords no firm basis for deriving particular probabilities. Of course, the facility of methods like Bayesian calculus can lead to assertions that "...it is always possible to obtain a probability...". As a result, the term uncertainty is often stretched to describe even relatively tractable conditions under which probabilities yield determinate answers.

However, the issues here are not about terminology, but the conditions themselves. If the term uncertainty is not used for this condition, there emerges a serious jeopardy of over-applying the concept of risk. When practitioners of a particular quantitative method insist on using their favoured techniques even when they are inapplicable, the result is a deep misunderstanding, understating indeterminacy and exaggerating the definitive power of calculation. The political pressures for closure in nexus-related challenges, discussed above, make this quite a pronounced syndrome.

For these same reasons, the difficulties in accepting challenges underlying the distinction between risk and uncertainty in nexus-related research, can become even more pronounced when attention is given to the horizontal axis in Figure 7. This highlights intractabilities in defining the divergent perspectives that might be taken on the possible outcomes that might arise. These challenges of ambiguity differ from uncertainty, because they apply even after outcomes have already occurred.

For example, much of the controversy over genetically modified organisms concerns not the likelihood of some agreed form of harm, but fundamentally different understandings of what harm actually means. This might variously involve threats to human health, ecological integrity, agronomic diversity, indigenous food cultures, sustainable rural livelihoods, vulnerability to climate change, control of intellectual property, or global industrial distribution.

Likewise in other areas of nexus-related research and appraisal around water infrastructures, contrasting pictures arise in focusing on different harmful mechanisms, toxic endpoints, or pathogenic vectors. How then does one define, bound, partition, and prioritize different possibilities? What sorts of questions should regulators ask: Do we need this? What would be best? What would be better? What would be safest? What would be safe enough? What would be tolerable? Or (as is routine in conventional regulation), the central question might simply be if some particular marketed product is merely "not worse than current worst practice"? Each of these contrasting questions is an indication of the scope for ambiguity, even in narrow terms of safety alone. Each can yield radically different answers.

Beyond risk, uncertainty, and ambiguity lies the final aspect of problematic knowledge in nexus-related research — ignorance. This is shown in lower right quadrant of Figure 7. Here, the challenge is not just about the prospect of radical surprise—"unknown unknowns" like newly recognized kinds of adverse outcome or harmful mechanism mentioned above. Crucially, this predicament is further amplified by the ways discussed earlier, in which production of nexus-related knowledges can themselves be conditioned by expectations and power.

An example of the kinds of artificial blinkers that can help generate ignorance in nexus-related appraisal, lies in the conventional framing of regulation of water, food and energy infrastructures. As discussed above, this tends to structure understandings according to the pros and cons of the particular innovation pathway favoured by incumbent interests. The resulting disproportionate focus of attention on mainstream interest can have the effect of reinforcing wider processes of lock-in and the crowding out of alternative institutional or innovation trajectories.

History is littered with cases where major – potentially very positive – infrastructure opportunities can be foreclosed. Examples might include QWERTY keyboards, VHS videos, narrow-gauge rail, urban automobiles, AC electricity, light-water reactors, and PC software. Even the most competitive markets repeatedly lock in to retrospectively clearly inadvisable choices. Whilst real world complexities ensure some degree of diversity, the repeated lesson of history is that society cannot commit to any single trajectory without

diminishing the potential for others. Artificially blinkered ignorance is itself one of the key mechanisms of closure. And those pathways of change favoured by the least powerful are typically the most excluded. These dilemmas can be especially pronounced in nexus-related research, where attention extends away from some single sector presenting a variety of quite obvious options, to the more complex ways in which food, energy and water infrastructures interact.

## **12: Institutions, Power and Closure**

The framework for understanding different aspects of uncertainty illustrated in Figure 7 above, offers a potentially useful way to understand the political pressures for closure discussed at the beginning of this paper. Here, it may be recalled, a frequent emphasis on the ‘real world’ needs of policy making or business ‘users’ of nexus-related research, tends to be interpreted as compelling delivery of relatively simple pictures of nexus-related interactions. For instance, ‘sound scientific’ approaches like risk assessment are assumed to deliver unambiguous ‘evidence-based’ prescriptions for policy.

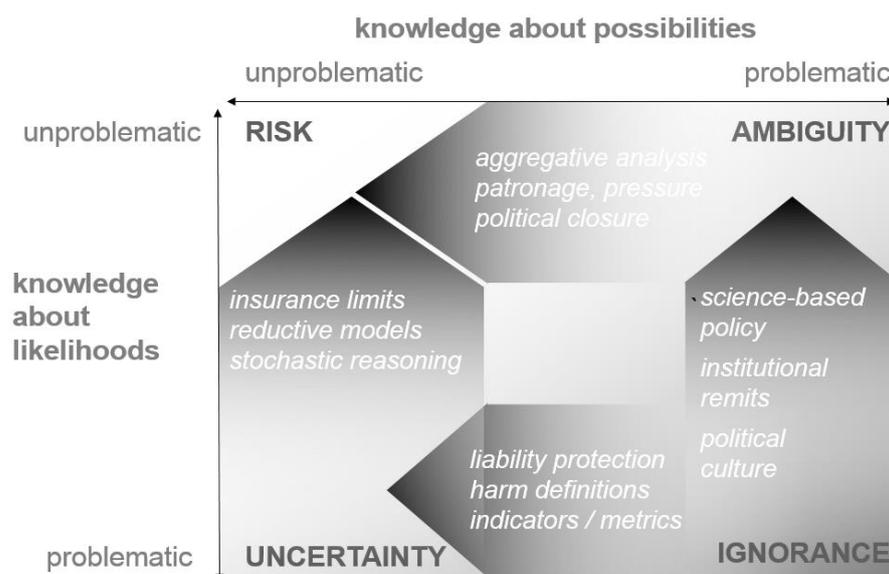
It was discussed there how these ‘real world’ imperatives for justification in government policy and business strategy can seriously misrepresent the ‘real real world’ of the nexus-related challenges themselves. But if nexus-related methodologies are to engage practically with the formidable material challenges, it is not enough that these pressures simply be decried. It is as important to address the complexities and power dynamics in subjective processes of understanding nexus-related interactions, as the notionally objective energy, water and food infrastructures themselves.

As shown in Figure 4, it is a key step in this direction to understand the general importance of framing. Any understanding of nexus-related challenges involves knowledge production of some kind. And it was shown in discussing qualities of reflection and reflexivity illustrated in Figure 5, that any rigorously scientific understanding must acknowledge that all knowledge – including that resulting from scientific analysis itself – is framed in some way or other. Figure 5 shows how this does not imply ‘anything goes’ relativism, but pragmatic realism of a kind that is essential to robust decision making in a field as important as decision making on the food, water and energy nexus.

What the framework in Figure 7 allows beyond this, is a more fine-grain appreciation for the particular ways in which pressures for closure play out. Some of the most important of these in nexus-related governance, are shown on the same framework in Figure 8 below. These political pressures are not necessarily bad. They are quite simply an unavoidable feature of existing political environments within which nexus-related decision making is undertaken – and research and appraisal commissioned. It is only by understanding and openly discussing this ‘fact of life’ that analysis and knowledge about nexus-related interactions can hope to achieve the forms and degrees of reflexivity illustrated in Figure 5.

In short, Figure 8 shows how the kinds of methodology that are typically adopted in nexus-focused research, do not simply reflect cognitive considerations, but institutional practices and cultures. In particular, the tendency to closure around risk-based approaches in nexus-related research, is not an indication of any deficit of understanding on the part of decision makers, but of the ‘real world’ pressures under which they work.

**Figure 8: Institutional Pressures for Closure in Nexus-Related Research and Appraisal**



For instance, a typical water or energy utility, operates under company legislation ensuring fiduciary responsibility to shareholders and a legal regime providing for limited liability. Together, these alone mean that the condition of ignorance is effectively removed from immediate decision making. Aspects of ignorance continue to persist unabated, of course. But limited liability and fiduciary responsibility mean that the key decision makers are not only absolved of considering them, but are often very strongly compelled not to – even sometimes at risk of being in breach of their legal responsibilities. Further institutional factors like insurance policies and contract law further move particular loci for nexus-focused decision making away from uncertainty and into a condition of risk. Alongside the political pressures for justification discussed earlier, it is for these institutional reasons, that unrealistically reductive risk-based approaches tend to be so persistently advocated and used in nexus-related research.

The crucial point in considering Figure 8 is, that the particular conditions (and associated logics) under which the typically emphasised ‘users’ of nexus-focused research operate, do not on their own necessarily provide a reliable basis for producing robust knowledge concerning the realities of nexus-related interactions and interventions. Because responsibility and exposure to the consequences is effectively (at least partly) externalised, due recognition is systematically suppressed, to crucial implications of uncertainty, ambiguity and ignorance. But these conditions themselves are not resolved. Indeed, they remain all the more potentially damaging for the fact that they are rendered less visible. And the consequences and costs of this insufficiently well-addressed uncertainty typically fall on the state and society at large – especially those whose marginal position in other ways tends to make them most vulnerable.

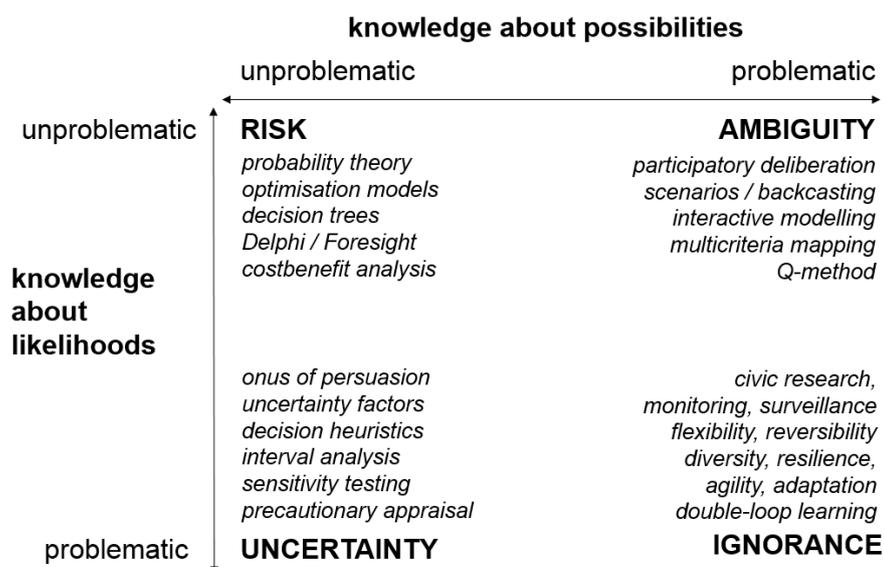
This is the general dynamic referred to by Ulrich Beck as ‘organised irresponsibility’. It constitutes a very poor basis for the governance of nexus-related challenges. It is for this reason that design of nexus-focused methodologies and the associated capabilities, must seek directly to counter the pressures for closure.

### **13: Some Practical Methodological Implications**

Such are the depths and scales of the political economic forces whose effects are summarised in Figure 8, that it might be thought naïve to envisage any kind of resolution at the level of methods and methodologies. Short of wholesale institutional change, how might these challenges in understanding nexus-related interactions be addressed? A discussion of nexus-focused methodologies and capabilities that simply assumed (or asserted) such conditions, might justifiably be thought somewhat impractical.

Fortunately, it is not necessary that the argument be left at this. In practice, there exists despite the institutional pressures shown in Figure 8, a rich diversity of methods for directly addressing dilemmas of uncertainty ambiguity and ignorance. These have been developed to a high degree of robustness and maturity in various field directly bearing on food, water and energy systems and their interactions. As such, they offer important ways to illuminate crucial implications of Nexus challenges. Yet, the pressures shown in Figure 8 nonetheless tend systematically to exclude these kinds of method – like Cinderella from the ‘party’ – from nexus-focused appraisal and research. Some important indicative examples of these neglected nexus-related methods are shown in Figure 9.

**Figure 9: Methods Addressing Different Aspects of Incertitude about Nexus-Related Challenges**



Some approaches shown in Figure 9 constitute entire families of methods, For instance, ‘participatory deliberation’ encompasses a very wide field of activity, within which there is considerable diversity. And this in turn spans a range of different practices, cultures and styles as illustrated in Figure 6. Also included in Figure 9 are more specific tools, like sensitivity analysis. Although often eschewed in particular fields (like cost-benefit analysis) by the ‘thick’ and ‘sticky’ culture of aggregation discussed above, these kinds of tools can in principle be used in alongside a wide variety of different methods.

Indeed, various kinds of sensitivity analysis, for example, offer means to articulate quantitative and qualitative methods in potentially very useful ways. They offer ways of addressing the heart of nexus-related challenges as identified here, by exploring the precise conditions governing how contrasting quantitative answers are arrived at under different qualitative assumptions. Indeed, particular hybrid methods like multicriteria mapping focus on developing exactly this kind of profound practical potential.

The crucial point in Figure 9, concerns the fundamental irrationality of so often restricting attention in nexus-focused research to reductive aggregative versions of methods like probabilistic risk assessment, cost-benefit analysis, life cycle assessment, ecosystem service valuation or optimisation models. These may have much to offer under circumstances thought to be adequately described by ‘risk’. But they are quite simply inapplicable under conditions of uncertainty, ambiguity or ignorance.

Here, 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.

And it is here that the precautionary principle also offers a crucial methodological guide that is both practical and rigorous. This simply reminds that decisions under uncertainty cannot by definition be based on notional trade-offs between risk and benefit. This is because trade-offs are indeterminate under such conditions. Rather than pretend at single-point confidence, then, what is needed instead, is more explicit, deliberate and inclusive attention to the latitude left by uncertainty for adoption of equally-valid, but divergent, values in decision making.

Under ambiguity, the scientific case for making use of different methods is even stronger. Here, nexus-focused governance faces questions over how to order entirely different dimensions of decision making. Even when attention is restricted simply to health factors, such dilemmas might involve, for instance, weighing up occupational disorders, childhood illness, environmental disease and other forms of morbidity. Each of these individual criteria might quite fairly be seen as largely a matter for technical expertise. But deciding between such questions still requires intrinsically subjective judgments.

Likewise, what kinds of aggregative quantitative method or expertise could plausibly settle the relative importance of compared levels of, say: Injury or illness? Effects involving adults or children? Worker or citizen wellbeing? Impacts on present or future generations? Harm to humans or animals? Here, Nobel-winning work in rational choice theory shows, as a matter of logic, that there exists no general form of analysis that can guarantee uniquely optimal answers across specific cases. It is under these circumstances that techniques come to the fore like the many kinds of participatory deliberation, scenario analysis and backcasting, interactive modelling, multicriteria mapping and tools for exploring different perspectives like q method.

And even under conditions of ignorance, where “not knowing what we don’t know”, might be thought to present hopelessly insoluble challenges, there exists a further extraordinary variety of practical methods. Again, these are side-lined by the political pressures for closure in nexus-focused research, around aggregative tools shown in the top left hand quadrant of Figure 8. Important practical methods for addressing ignorance include the many forms of citizen science and civic research (to pursue inconvenient questions), a priority on environmental monitoring and surveillance (to pick up surprising developments) and the systematic analysis and prioritisation of qualities like flexibility, reversibility and diversity. Again, the value of these approaches is not recognised under powerful pressures for closure. Only by resisting these pressures can nexus-related methodologies address the associated challenges.

## **14: Broadening Out and Opening Up Nexus-Related Methodologies**

One way of summarising the methodological implications of uncertainty, ambiguity and ignorance, is that they establish needs radically to '**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 (as discussed in Section 5), 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.

One way to think about these challenges is as twin quality criteria that apply respectively to the 'inputs' and to the 'outputs' of nexus-related research and appraisal. Here, '**inputs**' refers to a wide range of different factors that are taken into account. First, there are the institutional, policy and/or technology **options** that might be considered as possible interventions in food, water and/or energy systems and infrastructures. Second, there are the relevant **issues** that are attended to as potential pros or cons (benefits or impacts) in researching or appraising these options. Third, there are the **knowledges, values** and **perspectives** of the contrasting interests and constituencies that are interested in the implications or who stand to be affected by the consequences. Fourth, there are the kinds and degrees of **risks, uncertainties, ambiguities** and **ignorance** that are variously held to be associated with each of these options and issues under these perspectives. And, of course, all of these factors can be elicited and interrogated by the wide range of different **methods** and **methodologies** discussed here (Figure 6), so methods and methodologies themselves – and their associated values, interests and communities of practice – may also be considered as 'inputs' to research and appraisal.

The '**outputs**' of nexus-related research and appraisal, on the other hand, comprise the results, findings, recommendations or prescriptions that are variously communicated to decision makers, policy debates or wider political discourse. These will vary in nature, depending on the context. In a typical integrated assessment or exercise in risk analysis, for instance, they might comprise evaluated levels of benefit or impact or risk according to different possible metrics. In a policy or technology assessment, they might take the form of alternative possible strategic interventions and their respective implications. In an infrastructure or regulatory appraisal, they may involve assessments of a range of possible benefits or harms associated with contrasting investment options.

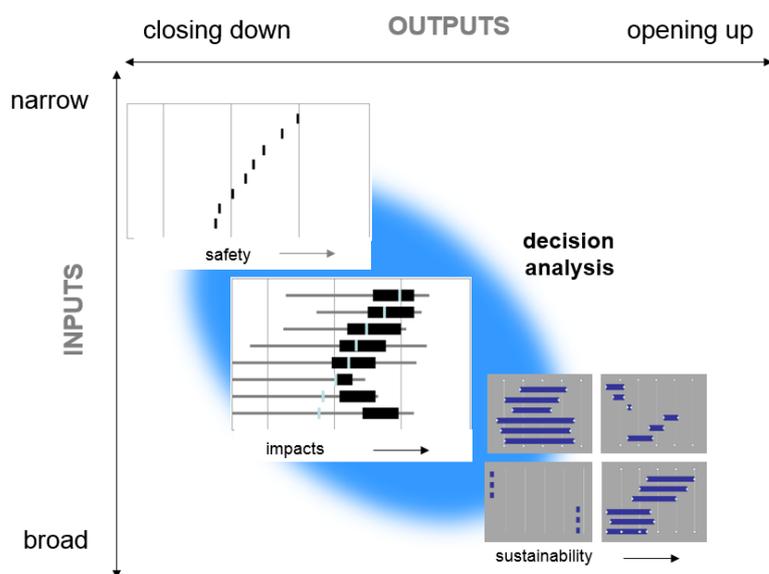
The earlier discussion of qualities of reflection and reflexivity in nexus-related research and appraisal (Section 9) underscores two quite distinct ways in which both inputs and outputs may be rendered more robust. In order to help provide confidence in the validity and completeness of appraisal and the reduction of error, inputs to research and appraisal can be 'broadened out' to be as comprehensive as possible – minimising the number and importance of factors that are omitted from consideration. In order to enable a requisite degree of reflexivity, on the other hand, outputs of research and appraisal should have the effect of 'opening up' wider political appreciations of the 'plural and conditional' nature of relevant knowledges and their implications for policy. So, in these terms, nexus focused methods as implemented in practice, may be thought variously broad or narrow, open or closed.

What 'broadening out' might mean in practice will typically depend in part on the particularities of a given method. For instance, research and appraisal of nexus-related challenges (including many kinds of 'analysis', 'assessment' and 'evaluation') might usefully include a wider range of institutional and policy options (including non-technological strategies), issues (including less readily quantified impacts and benefits), conditions (possible states of the world, scenarios or envisioned possible end-points), knowledges and methods (including from humanities and creative arts), and wider societal perspectives under which all these factors might be appraised (including those of usually-marginalised groups).

Figure 10 uses images from the meta-analysis of energy assessments shown in Figure 2, to illustrate what broadening out and opening up might mean in practice for a particular kind of appraisal method – in this illustrative case: decision analysis. The two axes demarcate a two dimensional conceptual space within

which various decision analytic methods may be positioned so as to represent their respective relative contributions to ‘broadening out’ or ‘opening up’ wider appreciations of nexus-related dynamics and their implications. Although nominally a quite distinct family of methods, decision analysis actually comprises a quite large diversity of different frameworks, techniques and tools. This diversity (and the detailed ways it is instantiated in any given research or appraisal exercise) means that it is impossible to think of even a single apparently quite specific method like this as occupying a discrete point in this notional space. It must instead be represented in the space as a distributed field (in this case, the blue oval), indicating the scope for latitude in design and implementation. Variations in this can have the effect of significantly altering the breadth or openness of this method in practice.

**Figure 10:** ‘Broadening Out’ and ‘Opening Up’ in Variants of a Particular Nexus-Related Method



For instance, a decision analysis might focus only on the single narrow criterion of human safety and represent results as single point numbers for each option. Here, the resulting picture might look like that shown in the top left of the blue field in Figure 10 (resembling the indicative single study shown in grey in Figure 2). This is relatively narrow in its inputs, because only expert based perspectives are applied, uncertainties are neglected and criteria other than safety are not considered. And it is closed in its outputs, because results are expressed with great precision and no uncertainty ranges.

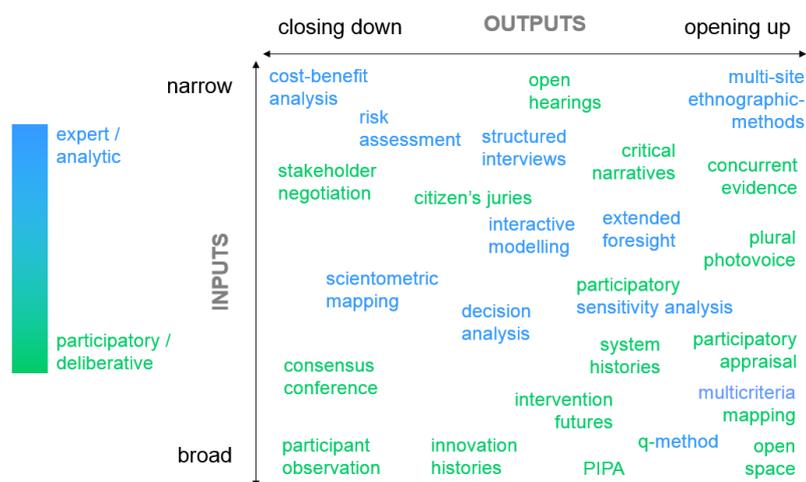
Alternatively, a decision analysis might pay attention to a wider range of impacts, address a diversity of framing assumptions in analysis and represent associated uncertainty ranges. The resulting picture in the middle of the blue field in Figure 10, is closer to the full meta-analysis shown in Figure 2, indicating a high degree of overlap between options in relation to this criterion of impact. This is broadened out, because issues are taken into account other than safety alone. And it is opened up, because policy debates are given a more full picture of the overall scales of combined uncertainties and ambiguities.

Finally, a different implementation of decision analysis might yield results more like those shown in the lower right of Figure 10. Using a particular decision analytic method called multicriteria mapping, each chart represents in detail one of four different indicative stakeholder perspectives, each appraising the same set of options according to whatever are salient criteria of ‘sustainability’ under that perspective – addressing pros as well as cons of the appraised options. The pictures are comparable, because options are defined similarly in each case and because what is being compared are the ordinal performance orderings of the different options relative to each other. Comparisons between the charts illuminate implications of ambiguities between perspectives. The relative lengths of the intervals for each option within each chart indicate the relative magnitudes of uncertainties under each perspective.

This lower right hand picture is the most broad-based in its inputs, because sustainability encompasses a far more diverse array of considerations than ‘impact’ or ‘safety’ and because each perspective has been enabled to express these in whatever ways it finds most appropriate. It also enables a greater ‘opening up’ of wider policy debate, because it distinguishes the detailed implications of each perspective. Behind these quantitative graphs, further qualitative information is also produced by this multicriteria mapping method, to illuminate the particular reasons why options rank differently under contrasting perspectives. This indication of the contrasting qualitative conditions implicated in different interpretations of the evidence, further opens up the picture in the lower right. It is in these kinds of ways that a given family of methods like decision analysis may display radical differences in where they might be positioned in the methodological space defined by ‘broadening out’ and ‘opening up’.

With the important caveat indicated in Figure 10, concerning the extended distributions typically displayed by any given method in this space, Figure 11 suggests the approximate relative positionings of notional ‘centroids’ for distributions representing a wide range of different nexus-related methods from among those reviewed in this paper (and listed in Figure 6). The selection represented here, includes indicative examples equally of expert/analytic (blue text) and participatory/deliberative (green text) methods. This underscores the point that the broadening out of inputs and the opening up of outputs are each qualities that are largely independent of expert-based or more participatory styles. Each may be variously narrow or broad in its inputs (top to bottom). And on the horizontal axis, each may equally aggregate diverse considerations and reduce them to an apparently precise representation (closing down) or disaggregate these and represent them in plural and conditional form (opening up).

**Figure 11: Qualities of ‘Broadening Out’ and ‘Opening Up’ in Contrasting Nexus-Related Methods**



One key feature of this way of representing different nexus-related methods, is that it provides a clear way to illustrate schematically some crucial practical **normative** implications for policy. The axes in Figure 6, by contrast, was more neutrally **descriptive**. It displayed contrasting styles (inductive, abductive, deductive), cultures (qualitative, quantitative, hybrid) and practices (expert analytic and interactive deliberative) – all parameters that were argued in principle to be equally positively applicable to nexus-related challenges, albeit in complementary ways and depending on details. The discussion at that point was simply an exercise in discriminating qualitatively different kinds of method and illustrating the scope of this survey. The point now is to draw some practical prescriptive conclusions concerning the kinds of methods and methodologies that offer more rigorous, robust ways to help address nexus challenges.

## **15: The Politics of Nexus-Related Methodologies**

This said, a crucial point to make about Figure 11, is that the purpose is not to substantiate judgements on individual methods. As mentioned, the positions indicated here are of notional centroids of far more extensive possible distributions in this normative space. So, it is nonetheless possible to derive from this picture – even under the same notions of broadening out and opening up that define the axes – quite radically different preference orderings than suggested by the precise positionings of names. The point here is rather to concretely illustrate the general meanings of the normative qualities themselves as a methodological frame, than to make firm or precise prescriptions about specific methods.

Nevertheless, it follows from the argument set out in this paper, that the qualities of reflectiveness, reflexivity and social robustness in nexus-related methods are – in general – significantly advanced by qualities of broadening out inputs and opening up outputs. So, a clear normative general point may thus be made about broadening out and opening up. Unlike the purely descriptive ordering of styles, practices and cultures shown in Figure 6, then, Figure 11 holds explicitly prescriptive implications. All else being equal, the further to the lower right that a given instantiation of a nexus-related method might be positioned in Figure 11, the more robust and rigorous it is argued to be as a general candidate method for contributing positively to understandings of food, water and energy interactions.

Of course, this picture is complicated by the many dimensions for complementarity and synergy discussed earlier. Even where it might be located at the extreme lower right, no single method on its own will satisfactorily address all the many aspects of food, water and energy interactions, even in a given setting. As discussed in Section 5, methods fit together in various ways over time and space and according to other logical structures (such as specific functions). So methodologies prioritising broadening out and opening up will nonetheless tend to articulate methods from different areas of this space, depending on specific attributes within this host of more complex wider considerations.

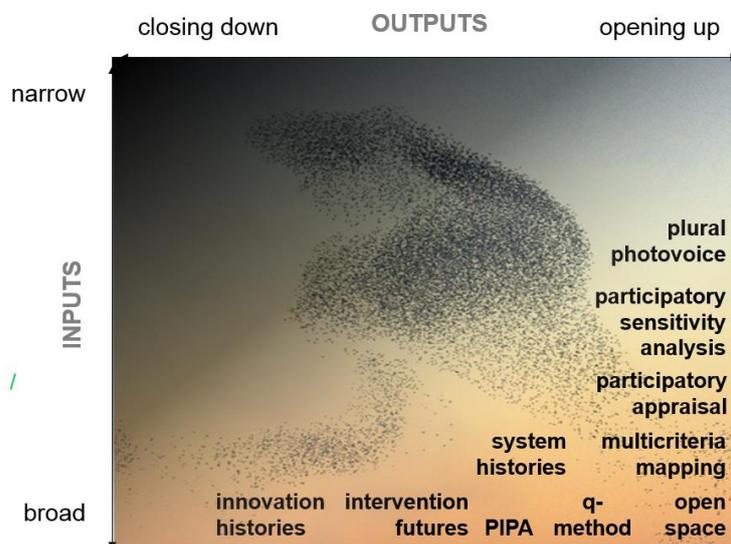
Yet despite such complexities in the details, what Figure 12 illustrates quite nicely is a more general field (beyond the more particular picture described in relation to uncertainties in Figure 8) within which political pressures typically tend to operate quite strongly. In short (as with uncertainties more specifically), various kinds of power tend (depending on the setting) to exert pressures on nexus-related research and appraisal, such as to condition the presentation of results in ways that best provide the precious political resource of decision justification. As Margaret Thatcher (and many another politician) is apocryphally reported to have pleaded, “give me a one-handed economist”. As mentioned earlier, these are the particular ways to help foster trust, command authority, secure acceptance and manage blame. Under the many associated incentives and penalties of policy patronage structures, there is no shortage of more instrumentally-inclined disciplinary cultures – or even individuals – often with their own internal propensities to heroically precise forms of closure, that are typically happy to oblige.

These political pressures may be expedient in providing elite policy actors with ‘real world’ resources for fostering trust, commanding authority, securing acceptance and managing blame. But this kind of closure risks seriously misrepresenting the ‘real real world’ complexities and uncertainties of nexus-related interactions and interventions themselves. As a result, methods in the top left corner may help reinforce the relational positions and privileges of incumbent policy actors. But they risk leaving resulting decision making highly brittle in the face of excluded complexities.

This is an aspect of the phenomenon referred to by Beck as ‘organised irresponsibility’. The associated timescales and typical indeterminacies around individual responsibility may make this exposure of relatively little concern to individual policy actors. In any case, no method is ever sufficient to remove the key challenges of policy making – again apocryphally expressed by another former British Prime Minister, Harold MacMillan) as “events, dear boy, events”. These challenges are not so much about exercising real control in the world, but successfully surfing the waves of contingency such as to sustain the illusions of control that are so central to maintaining political privilege. This is why brittle forms of closure need not present undue threats to decision makers themselves. But the wider stakes are large indeed. Societies in general – and especially the most vulnerable people – have much to lose. It is precisely and especially the poorest and

most already-marginalised people – most removed from the dynamics of methodology design – who are most vulnerable to resulting kinds of shock and surprise.

**Figure 12:** ‘Broadening Out’ and ‘Opening Up’ more Democratic Nexus-Related Research and Appraisal



If the building of capabilities for nexus-focused research and appraisal aims to resist these expedient and potentially dangerous political pressures, then, it must seek deliberately and actively to compensate for the distorting effects of closure. Alongside the many other considerations mentioned above, methodological design processes can – despite the policy disincentives – prioritise methods in the lighter-shaded regions on the lower and right hand sides in Figure 12. These are the broader and more open types of methods that promote qualities of scope, transparency and accountability in wider political discourse. Unlike conventional methods for narrowing in and closing down political spaces, these broader and more open methods do not seek to emulate the aspirational ‘eagle eye view’ of incumbent policy actors in order presumptively to ‘see like power’.

Instead of providing political resources for elite incumbents to defend their interests and maintain illusions of social control, these broader and more open nexus-related methods help to open up greater political space for wider and deeper forms of critical discourse and challenge. And interestingly, such are the natures of complex social nonlinearities and fractal flows of power, that there may often arise specific circumstances where the ostensibly most high status decision makers are actually more like captives of incumbent structures of incumbency, than they are protagonists of control. Many is the Minister, who is actually more an object of agency by surrounding communities of senior civil servants and other gate-keepers, than the apparently heroic controlling subject (of a kind that all will work so hard together to present to the wider world). Under these circumstances, methodologies allowing an opening up of the above kinds of uncertainty and ambiguity, may (if they can penetrate the protective political carapace) actually find very highly-placed allies – and perhaps surprisingly grateful audiences.

So, despite the explicitly politically-informed nature of this discussion, there is nothing about these general prescriptions for the ‘broadening out’ and ‘opening up’ of nexus-related methodologies, that are in any particular sense politically partisan. Similar basic dynamics apply, irrespective of specific evaluative, institutional or socio-political interests. All that is required is that attention be given in a serious analytical way, to the simple fact that nexus-related research and appraisal – like all ostensibly neutral academic and policy processes – actually take place in environments pervaded by interests and power. It was in order directly and explicitly to address this often-neglected real-world dimension of nexus-related methodologies, that Figure 4 above highlighted that subjective dynamics of framing in systems of scrutiny, are as crucial to methodological design as apparently objective dynamics in the systems under scrutiny. Indeed, it is the

neglect of this crucial reality that actually constitutes the most politically partisan of positions – simply resulting in alignment with whatever happens to be the particular incumbent interests that such dynamics serve to benefit in any given setting.

Nor need these prescriptions for broadening out and opening up be seen as unduly burdensome – or consuming of time or resources. Indeed, quite the opposite can be the case. Under real-world pressures for justification, it is often the forcing of unduly precise levels of precision, or imperatives to perform overly-voluminous forms of authority, that actually cause the most serious delays and expense. Where there is a recognition that policy research and appraisal can only ever deliver plural and conditional outputs to policy, then some of the time- and resource-consuming pressures can be alleviated. By acknowledging complexities, uncertainties, ambiguities, forms of ignorance – and all their resulting conditionalities, nexus-related methods may actually serve to relax some of the pressures on appraisal. The burdens of justification fall instead on the processes of decision making – to take responsibility and be accountable for the resulting commitments, rather than seek to externalise these onto processes of research or appraisal.

Of course, the world is a complex place and these kinds of relatively benign dynamic may certainly not apply in many cases and settings. It definitely can be true that broadening out and opening up nexus research and appraisal may sometimes be inconvenient or involve additional complications. But where the goal is not convenience and expediency but rigour and robustness, such prosaic priorities may nonetheless take second place to the aim of properly representing the best available knowledge concerning food, water and energy interactions. So the point here is not that such difficulties may not apply from time to time, but that burdens of time and expense need not be any worse than is already the case where policy demands highly ambitious forms of artificially closed authority and precision.

This leaves one final possible concern to address. Might not resistance in nexus research and appraisal, to political pressures for justification and closure, actually have the effect of paralysing decision making? Would this not constitute a potentially serious obstacle to progress, in a field where there are such compelling imperatives for transformative change?

Here, it has to be conceded that this might be the implication under conventional notions of social control as the primary means for societal change. This would indeed be so, if it really were the case that transformative progress of the kind now sought in the face of nexus-related challenges, only arises through top-down vertical structures of privilege, of the kind usually associated with such pictures of control. But the point has already been made, that this portrayal of governance-as-control is itself understandable as an artefact for justification. The lessons of history were already introduced at the beginning of this paper, under which it is at least questionable whether any kind of radical progressive transformation of the kind now sought, is ever achieved solely in this way. Referring to socio-cultural changes like unfinished and faltering moves away from slavery, serfdom, worker exploitation, colonialism, racism, sexism and homophobia, it can be appreciated to be far more likely the case, that successful progressive transformation of systems of practice and provision around water, food and energy needs will be driven by collective action in wider political arenas.

It is precisely this potential for effective progressive collective action that a broadening out and opening up of nexus-related methodologies may hope to help achieve. By resisting pressures for justificatory closure, this helps avoid incumbent interests shaping processes of nexus-focused research and appraisal and framing their results, in ways that are most locally expedient. This is why the point has been made repeatedly, that the target arena for nexus-related methods is not just policy, but politics. This is the only position to take, that is truly consistent with academic responsibilities for independence and disinterested rigour. And this is the reason for the image of flocking birds in Figure 12. It is insistence otherwise, that nexus-focused research and appraisal should always do the bidding of whatever happens to be the most powerful ‘users’, that is the real politically partisan position. In short, by broadening out and opening up nexus-related methods and methodologies, researchers and policy analysts may at the same time hope to achieve greater scientific rigour and democratic accountability.

## **16: Towards Transdisciplinary Capabilities**

It follows from the preceding discussion, that the 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.

It does not require an unduly 'critical' approach – let alone any denigration of individuals (elite or otherwise) – to recognise the more unqualified versions of this picture as sentimentally romantic, politically expedient and structurally self-serving. Even where the language of '*sound science*' or '*technological fixes*' is ostensibly more nuanced – even decried – an abiding instrumental thrust typically remains around underlying drives for '*evidence based policy*' for '*scaling up*' '*pro innovation*' diffusions of '*technological solutions*'. The point here is not that evidence is not necessary – even essential – just that it is typically insufficient. And the argument is not against larger scale ambitions for progressive nexus-related change, just that these should pay greater attention to diversities of settings and pluralities of perspectives. Above all, the idea is not that innovation is not crucial, but that it is often more about social, organisational, behavioural and cultural change than about technology alone. And even with regard to technology itself, the conclusion is not that diverse technologies in general cannot constitute crucial parts of solutions, but that the framing of aims too exclusively this way, can open up a massive vulnerability to special pleading, organisational capture and lock-in.

These arguments are not particularly or self-consciously 'critical'. They are simply realistic about the power-laden nature of the social environments within which nexus-related knowledge is produced and policy trajectories become committed. Nor do they imply that power imbalances of whatever kinds are necessarily somehow a negative thing. Asymmetric power relations are simply a fact of life – indeed perhaps the single most important general social fact. Whether it is criticised or celebrated, power is, quite simply, a reality. And the key point is, for better or worse, that power has consequences. Whether these may be positive or negative in any given context will typically depend both on the particular setting in question and the perspective that is taken on this. But to simply ignore the manifest imprint of power in nexus-related knowledge production and innovation, would (perhaps more surely than anything else), leave nexus-related research and appraisal open to serious error and manipulation.

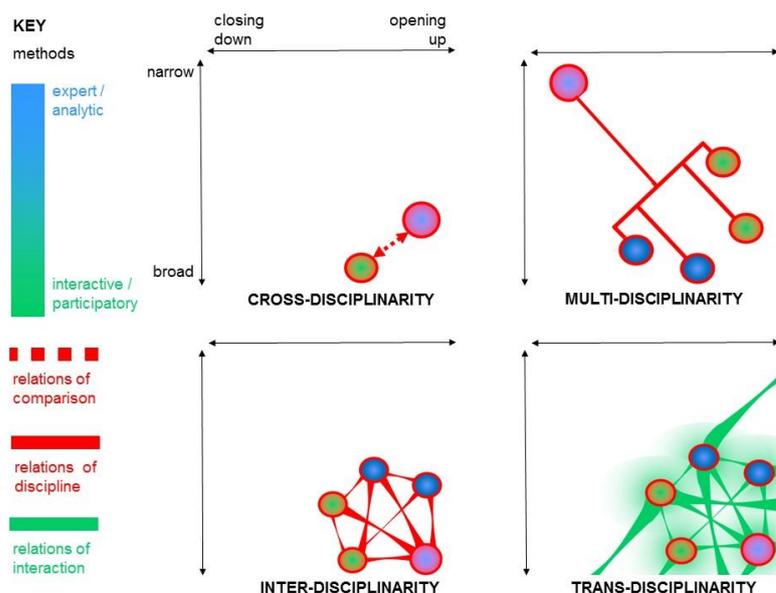
So what are the practical implications for concrete nexus-focused methods and methodologies of this more explicit and realistic recognition of the roles played by power asymmetries in scientific research and knowledge production more generally? Here, attention turns back to earlier discussion of the different ways in which nexus-related research and appraisal require different disciplines to engage together. The question now is, what particular processes and structures of cross-disciplinary collaboration, can best address these challenges presented by power-in-knowledge? Before turning to some of the more fine-grain points in the final recommendations, this penultimate section of this paper will examine the implications for what might be meant by "trans-disciplinary nexus-related research".

Earlier discussion in this paper distinguished: ***cross-disciplinarity*** – as the ad hoc linking and comparison between different disciplines; ***multi-disciplinarity*** – as the systematic adding together of contrasting disciplines in structured ways; ***inter-disciplinarity*** – involving more intimate and detailed syntheses of divergent elements from different disciplinary frameworks; and ***trans-disciplinarity*** – allowing problems to be framed and potential responses defined from the outset in equal partnerships between researchers and other interests spanning disparate business, government and civil society perspectives. What is added to this by a general awareness of power (and the various process of justification and closure discussed throughout this paper), is a focus on questions of balance, equity and fairness in these relations. Who does what? Who leads? Who follows? Who has which kinds of agency?

Figure 13 provides a simplified schematic picture of some key further responses to these questions, of kinds that have potentially profound implications for provision for practical capabilities for nexus-focused research

and appraisal. It uses the conceptual field explained above, emphasising the benefits of broadening out and opening up understandings of nexus-related challenges. Retaining the applicability equally to expert-analytic and interactive-participatory methods (as well as the other distinctions illustrated in Figure 6), Figure 13 indicates the contrasting kinds of relation that are typically most prevalent in this different modes of cross-disciplinary engagement. Even where a priority is placed (as recommended earlier) on methods for broadening out and opening up nexus-related understandings, Figure 13 shows that the nature of the cross-disciplinary relations (the linking lines) can also matter as much as the positioning in this space (towards the lower right hand side).

**Figure 13: Contrasting Relations between Disciplines and Methods in Nexus-Related Research**



As Figure 13 shows, **cross-disciplinarity** involves associative relations between different methods that are primarily comparative. Power is typically exercised simply in selecting and constituting the methods in question. In **multi-disciplinarity**, relations are usually centralised and hierarchical – employing power to impose ‘discipline’ in research, in the colloquial sense of this word. So, a particular discipline (in the academic sense, along with its associated methods) is privileged in the framing of enquiry, the ordering of other methods and the final overall interpretation of results. In **inter-disciplinarity**, by contrast, relations between disciplines are more symmetrical and equal – different methods may be used to address contrasting aspects of a nexus-related challenge. But, even if participatory practises are employed in later parts of the process, non-academic interests are often excluded in crucial processes of designing research, framing questions and interpreting findings. It is only in **trans-disciplinarity** (as defined here) that research or appraisal engages in broad, deep and equal ways with disparate interests who are normally left outside formal processes of policy research. Trans-disciplinary engagement does not simply take place within disciplines. Nor is it just that individual methods are implemented in ways that are subject to wider engagement. The point made in the lower right of Figure 13, is that the design, implementation and interpretation of the entire research or appraisal process, is conducted as an equal collaborative partnership with disparate wider interests beyond the practitioners themselves.

## **17: Some Practical Implications for Nexus-Focused Research**

The practical implications of the above distinctions are too many and detailed to do justice to here. But the main point, is to challenge familiar rhetorics of inter-disciplinarity, in which these kinds of distinction are not only not made, but not even contemplated. This leaves a serious vulnerability that crucial features of nexus-related research or appraisal will not only be misunderstood, but actively misrepresented. But deeper questions are also posed by this analysis, for the conventional ways in which research is organised, peer review is conducted, academic excellence is recognised and impacts achieved. And there are also profound challenges for notions of ‘usefulness’, ‘user’ and ‘impact’ – each demanding queries over “according to whom?” and “why?”. It is typically much easier, for instance, to demonstrate ‘usefulness’ or ‘impact’, where methods are aligned with the most powerful proximate interests. Understanding the importance of power relations in trans-disciplinarity means recognising that neutrality and independence is not about simply gauging locally intermediate positions, but deliberately highlighting plural and conditional findings and active challenge of power-in-knowledge.

It has already been shown that merely recognising and challenging power relations in this way, should not necessarily be seen as exclusively or self-consciously critical. The point here is more practical, that addressing power in this way, is the most constructive way to address nexus-related challenges. But if not seem too critical, the point may for some seem a bit abstract. To these, the above implications for choosing methods and ordering their relations might be thought answer enough. And more specific lessons for provision for research capabilities are discussed in the next section. But it might nonetheless be helpful here to give a concrete example of the ways in which power typically operates in nexus-focused research and appraisal, such as to privilege certain kinds of intervention and side-line others. It is this, that is best addressed by the kinds of power-challenging trans-disciplinarity called for here.

The example is drawn from a chapter for the recent UK Chief Scientist’s Annual report. It concerns a topical area where nexus-related challenges are currently intensively discussed: global land use. Here, the pressures and tensions are very strong between imperatives for production of sustainable food, renewable energy and high quality water. A series of high-profile, systematically-structured global assessments have looked at related challenges from different angles. Much essential information has been developed, with compelling implications for policy and wider politics. But it is nevertheless the case, that none of these high-level assessments have explicitly discussed the approach taken to power distributions within their own process. Since the procedures and communities involved are scientific, it is implicitly assumed (and tacitly claimed), that the processes in question are effectively power-free. Of course, such an impression is not only misleading, but wrong. And the practical dangers for effective responses to nexus-related challenges are all the more acute for being so typically unquestioned.

So what does this matter? Well, the imprint of disciplinary hierarchies within these kinds of assessment can be seen, for instance, in the prominence of reductive notions of ‘sustainable intensification’ of land-use. Although it is very welcome that attention is often given to wider kinds of innovation, the focal interventions in this literature are far more often technological, than they are social or organisational or behavioural or cultural. It is technologies, after all, that are most strongly favoured in incumbent infrastructures, where the most privileged interests rely on control of associated benefits. Without any deliberate bias, these wider power structures can be strongly reflected in the standings of different disciplines (like engineering and natural science) within nexus-related research and appraisal.

Beyond this, though, much nexus-related research tends to further privilege a few very particular technologies rather than others. Again, without any need for deliberate bias, this can occur simply as a reflection of the wider political economy. For instance, transgenic seed production for both energy and food use is typically a major highlight of attention, including for reasons associated with food, energy and sustainable water production. It is transgenics that best allows appropriation of intellectual property in particular gene constructs and the moving of these across species in ways tailored to other products in global value chains (like herbicides) such as to accrue maximum market rents.

This increasingly intense emphasis tends to side-line even other kinds of high technology intervention – like advanced conventional breeding or marker assisted selection (which do not present the same kinds of

opportunity for realising private shareholder value). Ironically, it is marker-assist technologies (like the so-called 'scuba rice' largely funded by DFID) that often offer the most promising examples of drought or flood - adaptive strains potentially most relevant to nexus-related challenges. Yet even public organisations like DFID, with ostensibly little direct interest in intellectual property or rent on value chains, nonetheless second-guess these wider interests by themselves more strongly advocating transgenics than their own more successful innovations. This kind of bias in a government department, can also apply in many apparently independent public research exercises on nexus-related issues.

Indeed, even other kinds of genetic modification beyond conventional transgenics can also be somewhat marginalised in much nexus-related research and appraisal in this field. Examples might include cisgenics, where the restriction of gene transfer within species may yield wider benefits but inhibit the realising of commercial gains. Or potentially transgenically-achievable properties like apomixis are also often under-prioritised, because the benefits more likely fall to farmers in enabling them to select their own locally best-performing varieties, rather than purchasing proprietary seed.

But the most serious effect of this kind of bias in ostensibly independent nexus-related research and appraisal relate not to technology, but to wider forms of innovation. As is documented further in the chapter for the UK Chief Scientist's report, some of the most effective nexus-related innovations in this field include participatory breeding, agricultural extension services and open source seed sharing, which harness the innovative capacities of farmers themselves and help tailor crop development to important local conditions. Likewise, many innovations in wider agricultural practices also offer significant benefits to the productivity of the globally-crucial population of small farmers – including intercropping, integrated pest management and other methods of ecological farming and sustainable agriculture. It is the reflection of external political economy in internal power relations within research and appraisal processes, that can strongly marginalise these kinds of innovation in much nexus-focused activity.

The same picture is even more pronounced for broader kinds of social innovation, which may hold great importance for addressing nexus-related challenges, but which tend to be downplayed. Examples include organisational innovations in the food chain like reforms to distribution systems, storage provision and better food waste management. Arguably the greatest implications for equitable global food availability under water and energy stresses, however, are presented by innovations that are even wider in scope, including reforms to land tenure and agricultural property rights, income support for marginal farmers, social equality between different rural groups, or moving diets towards lower meat consumption. These kinds of innovation may often offer significantly greater benefits to poor farmers, consumers or communities than science-intensive technological solutions. But their less attractive commercial benefits mean they remain, like Cinderella, too often uninvited to the nexus-related innovation party. The key point is, that it is difficult to remedy this kind of bias, if power relations within research and appraisal are not discussed and more effective trans-disciplinary responses developed.

There is one final practical point in thinking about how trans-disciplinarity can address challenges of power in nexus-related research and appraisal. This concerns the appropriate roles for social science. When and how, should social scientists take a lead? Merely in the final communication of results? In eliciting options, weights or priorities as inputs? In investigating issues of use, practice, or compliance? Or (as here) in illuminating dynamics of power in the social processes of science itself?

Answers to this question themselves reflect power relations within processes of research and appraisal. The case is easily made (and quite readily accepted) for instrumental forms of social science that assist the implementation of whatever interventions are favoured by wider incumbent interests. But when social science raises the present kinds of question or seeks to address the inherently social nature of nexus-related research itself, then it becomes more common to 'blame the messenger'. For instance, the highlighting of the profound importance of social framing mechanisms of the kind shown in Figure 4 – or their effects as shown in Figure 2 – can be highly inconvenient both to claims-making in other disciplines and to instrumental interests of policy making in decision justification. So, this latter kind of role for social science in trans-disciplinary research and appraisal is too often simply ignored – or even actively resisted. But without this, the importance of trans-disciplinarity cannot even be grasped.

## **18: Conclusions – Answering the Key Questions**

In concluding this draft working paper, there is a responsibility having raised so many complex critical issues, to answer the initial questions in as clear, concrete and practical a way as possible. But before turning to this final task, it may be useful to reflect again on the key findings of this analysis. First, there is the sheer scale of the challenges. Arguably never before has humanity as a whole sought to undertake concerted deliberate action of such progressive ambition and scale as is now required by nexus-related challenges – intentionally to transform global infrastructures and practices for provision of water, food and energy. Here, the lessons of past emergent transformations in progress around security, equality and sustainability are worth bearing in mind: success requires struggle. But the social and environmental imperatives are undeniable. So nexus-related responsibilities are unavoidable.

Yet there are grounds for optimism. There are precedents for progressive political change on this kind of scale. But here another message may be clear. This can be seen, for instance, in ongoing global transformations like those away from slavery, colonialism, racism, class and gender exploitation. Here, the principal drivers of change have lain initially and mainly not in formal academic understandings or integrated analysis – nor even primarily in ‘practical’ business strategies or structured policy processes. Indeed, academia, business and government have often been as much resistant as encouraging of change. Time and again, crucial engines of progress lie in ‘unreasonable’ bottom-up pressures in unruly collective action and mobilisation by social movements. So: success in tackling nexus-related challenges is arguably at least as much about catalysing radical politics, as informing orderly policy. Again the practical methodological implications for building nexus-related capabilities are both pragmatic and strong. But the conclusions might be somewhat different than in an analysis driven by conventional imperatives of policy justification of the kind that typically resist transformative progress.

So, what might all this mean in practice for the questions with which this paper began – as posed to the Nexus Network by the division of the UK ESRC concerned with planning for provision for postgraduate skills and training? What kinds of capabilities might be required for broadening out and opening up transdisciplinary methodologies for more effective understanding and action on nexus-related challenges? Here, we were posed two basic questions, which will then each be taken in turn:

**1: What kinds or mixes of method and methodology are needed to address nexus-related challenges?**

**2: What Are the Implications for Capabilities for Transforming Nexus-Related Politics?**

### **Question 1: What Kinds and Mixes of Nexus-Focused Method and Methodology are most Needed?**

A key message substantiated in this paper has been that no one kind or quality of ‘Nexus method’ can be complete or uniquely authoritative. Just as nexus-related challenges span diverse sectoral foci, disciplinary boundaries and institutional settings, so they demand a **diversity of methods**. Nor is there only one way of conceiving or ordering this diversity: nexus-related challenges also require **methodological pluralism**. In other words, transforming global systems for food, water and energy provision in integrated ways, requires capabilities not only to harness different kinds of methods, but also to design, interrogate, implement and interpret the resulting mixes of methods in different ways.

These findings arise equally with respect to the contrasting functions described in Section 5 (and Figure 1) – for instance to different tools, techniques and frameworks. They also apply to the various cross-cutting ways of dividing up contrasting kinds of method discussed in Section 10 (and Figure 6) – for example: **analytical** or **interactive** practices; **quantitative** or **qualitative** cultures; and **deductive**, **inductive** or **abductive** styles of reasoning. All these approaches are variously necessary in different perspectives or contexts. The value in maintaining capabilities for diversity and pluralism, is that particular disciplines or organisations typically take partisan positions in all these dimensions. A transdisciplinary approach, on the other hand, is simply by virtue of its greater diversity and plurality, in principle more flexible. This allows a

more practical and problem-focused approach to real world complexities. The resulting higher resistance to lock-in, can offer greater chances to be more rigorously symmetrical in evaluating different methods.

This said, there are two key kinds of quality that nexus-related challenges demand should be prioritised both in designing specific mixes of methods for different purposes and the methodologies through which these mixes are themselves designed. These might be called 'broadening out' and 'opening up'.

**Broadening out** refers to the 'inputs' taken into account in designing or implementing nexus-focused methods. This involves ensuring that methods:

- (1) address a comprehensive range of all relevant **issues**; fully explore the entire field of **uncertainties** typically associated with these issues;
- (2) focus attention on a complete set of strategic, policy and/or technology **options**; and
- (3) do all this by engaging in fair and balanced ways with the knowledges, values and **perspectives** of all interested and affected parties.

A key point here is that those socially marginal communities and economically vulnerable groups who are often worst effected by nexus-related pressures are also conventionally those who are most excluded in nexus-focused research and appraisal. So, progressive solutions to nexus-related challenges typically require methods to be broadened out in ways that are not merely 'representative' with respect to academic norms, but which directly counteract these imbalances by deliberately favouring the most excluded interests. If perils of justification are to be avoided, this means enabling direct **substantive participation** in processes of appraisal by the interested and affected people themselves.

The second essential methodological quality for properly addressing these nexus-related challenges is about **opening up** the 'outputs' of research and appraisal, in the ways results are communicated to wider policy debates. This means rigorously **documenting uncertainties, exploring ambiguities** and **acknowledging ignorance**. Where nexus research and appraisal are 'opened up', results are in a '**plural and conditional**' way, in the form "*if condition X holds, then action A is favoured; but if condition Y holds, then action B is favoured*". Adjudication between conditions X and Y is acknowledged to be an irreducibly political matter of framing, beyond the legitimate scope of expert analysis alone.

It is arguably only by these means that a balance can be achieved against '*real world*' political pressures for justificatory closure around a supposedly transcendently singular '*The Nexus*'. Instead, what can be aimed at by this plural and conditional approach, is a more explicitly political discourse about the '*real real world*' of the complex, uncertain, ambiguous interlinked nexus-related challenges themselves. In this way, what might be hoped to achieve is a kind of discourse on the food, water, energy nexus that is at the same time more scientifically rigorously and more democratically accountable.

### Question 2: What Are the Implications for Capabilities for Transforming Nexus-Related Politics?

This broadening out and opening up nexus-focused methods, requires some very particular wider capabilities on the part of researchers, practitioners and policy actors alike. There is a need to transcend divides and harness the synergies and complementarities between analytical and interactive practices; quantitative and qualitative epistemic cultures; and deductive, inductive and abductive styles of reasoning. But this requires more than just *ad hoc* cross-disciplinarity, or structured multi-disciplinarity, or even academic inter-disciplinarity. What are most needed in order to address interlinked food, energy and water challenges, are the many different capabilities that enable more socially engaged **trans-disciplinarity**.

A world of perverse incentives to academic and policy work, presents many formidable barriers to trans-disciplinarity. But the key obstacles to building associated capabilities do not primarily reside in any lack of understanding. It is typically not individual academics or policy makers who block progress. What are typically more important, are structural blinkers in discipline and academic and policy organisations. So remedies are as much institutional and political as educational or pedagogical. Some of the most important

required capabilities are not so much those of researchers or practitioners as professionals, but on the part of the social structures and cultures in which they work. A particular impediment lies in unequal power relations and structures of privilege, within and between disciplines.

A key point, then, is that these obstructive inequalities apply not only in policy interventions on food, energy and water challenges, but also in processes of researching and appraising these challenges. 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. Each of these capabilities will be slightly elaborated in turn.

**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.

**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 (tho' 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.

One cross-cutting aspect in all these capabilities, is greater general attention to diversity of many different kinds. Just as nexus-related challenges themselves are constituted by diversities of sectors, settings, interests and potential interventions, so preparedness to address these challenges requires further diversities of its own, in: methods, methodologies and capabilities. So, a crucial additional capability in its own right is the **governance of diversity** itself in nexus-related research and appraisal as in the strategies, policies and innovations that might be implemented in practice.

But, as has been emphasised here, there exists no single formulaic way to articulate these various kinds and dimensions of diversity. The most rigorous and effective means to realise whatever might be judged to be the requisite form and degree of diversity, will always lie grounded in contexts and settings of specific research or appraisal initiatives, accountable to particular disciplines, users and stakeholders. So a further important capability in any methodological tradition, is a caution over the implications of generalisation and a **sustained appreciation for the importance of the particular**.

This brings discussion at the end to perhaps the most important single general nexus-related capability. If the challenge of transforming global patterns of food, water and energy provision are to be taken seriously, there are important lessons from history. **Progressive change on such scale is unlikely to be achieved by expert research and hierarchical 'evidence based policy' alone**. Whatever the sincerities, associated institutionalised processes tend to be too vulnerable to lock-in and capture by incumbency. If progressive transformation is to be peaceful, what history shows to be more crucial, instead, is a general societal capacity for democratic struggle. Although this is a far deeper and broader issue than can be addressed by nexus-related methods alone, it does hold very important implications for them.

It follows from the need for caution in generalisation, that what these further capabilities might mean in practice in any given setting, remains a subject for ***continual critical challenge and accountability***. But there are a number of particular cross-cutting capabilities that remain meaningful across all the many disciplinary and cultural divides associated with the scores of methods reviewed in this paper.

First, that arguably the most important capability in nexus-focused research and appraisal is to prioritise informing ***politics not just policy***. It is broader political discourses, arenas and structures that most crucially constitute nexus decision making contexts. The latitude and inclinations of particular incumbent policy actors, communities and organisations are typically too restricted fully to address the necessary kinds of progressive transformative change. A key capability is to always remember this wider responsibility, even where existing institutions provide countervailing incentives.

Second, it follows that nexus-focused research and appraisal should orient actively towards a diversity of interests. Rather than disproportionately addressing the agendas of the most privileged 'users', neutrality means deliberately countering this bias towards the most vocal and powerful. Here, academic independence is not a transcendent virtue conferred by privilege, but a distributed emergent condition of plurality, always accountable to the particular diversities in which it is grounded. This faculty and appetite for active ***critical challenge of power***, is another crucial nexus-related capability.

Third, that rigour, robustness, authority and legitimacy in nexus-focused decision making can only come in the final analysis, not through the assertiveness and confidence of expert methods of analysis (even where these are transdisciplinary), but from democratic transparency, accessibility and accountability. In this sense, the most important nexus-related capability of all, is recognition that no nexus-related capabilities are sufficient to substitute this fundamental overarching ***imperative for wider democracy***. Of course, what this means in any given particular practical setting will always itself be a contestable struggle. But without this general capability, hopes for progressive transformation of global structures and practices for provision of food, water and energy may remain little more than self-serving rhetoric.