The synergies of difference:

Strengthening transdisciplinary research practice through a relational methodology

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Candidate's Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Elizabeth Clarke Date: 23 May 2016

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ABSTRACT

There is a growing body of literature addressing the challenges of transdisciplinary research – how to do it, what it is and who is doing it. At the same time there is growing discussion and awareness in international research about wicked problems and how to deal with problems such as sustainability, inequity, inequality, food (in)security, climate change and natural resource management. These problems are described as wicked since they defy complete definition, there are no final or simple solutions and any solutions are generally contested. A third body of the research literature focuses on transformational learning and knowledge creation capable of tackling contemporary social and environmental challenges.

Through the study of the lived experience of transdisciplinary researchers combined with theory synthesis, this thesis contributes to further understanding of all of these inquiry areas that I propose are inseparable from the practice of transdisciplinary research. The primary aim of the thesis is to improve understanding of transdisciplinary research practice and to bring together, synthesise and test a range of frameworks that can inform and guide this practice. The guiding aspiration for my research is to access the untapped potential of transdisciplinary research practice (the practice of the researchers) to investigate wicked problems in complex systems. While the context of the thesis is research for rural development, the application of the resulting methodology is far wider, including transdisciplinary research, sustainability science and other inquiry endeavours that tackle wicked problems.

Based on my own philosophical framing, one that combines constructivism with elements of critical theory, adopting a relational ontology and a pragmatist approach, I propose a relational and overarching transdisciplinary methodology in this thesis based on the following five principles:

> Principle number 1: A collective, inclusive approach to **appreciative, context-based problem framing** is needed to embrace the richness of complexity.
>
> Principle number 2: **Co-production of knowledge** across the boundaries of knowledge cultures and worldviews requires an inclusive, shared language for human and social inquiry.

Principle number 3: **Working constructively with tension** is a catalyst and foundation for transformational learning and change.

Principle number 4: An **iterative or recursive research inquiry process** is essential for transformational learning, and for theory and practice to constructively inform each other.

Principle number 5: **Reflection and reflexivity (both habitual and systemic)** are essential to enable the researcher to constructively capture transformational knowledge co-production.

These principles guide strategies to bring together vastly different worldviews, modes of inquiry and knowledge systems to create, not empty consensus, but a rich and innovative synergy for more constructive, engaged and effective problem solving. It is relational because the research practice focuses on relationships and networks and is dynamic. Underpinning this methodology (and the conceptual framework for this thesis) is an adaptation of Christopher Alexander's pattern language (Alexander, 1977) combined with elements of Layder's adaptive theory (2005). These two frameworks underpin my thesis research strategy with a cyclical, adaptive research approach where theory and practice inform each other, and where I synthesise sets of provisionally universal patterns as frameworks to identify and bring together specific patterns, and relationships between patterns, to form a series of ongoing solutions to wicked societal problems.

The empirical research in this thesis is based on a study of three case study research for rural development projects and the transdisciplinary researchers and participants in these project teams. Case Study 1 (seasonal climate forecasting for farming to enhance food security) is the pilot study, with Case Study 2 (family poultry production and crop integration for food security and nutrition) providing the canvas for the initial development and testing of the ideas and theory. The third case study (multi-scale climate adaptation for rice farming communities) is used to test the emergent theory and is studied in greatest depth, culminating in a detailed analysis using the principles that form the basis for the transdisciplinary methodology.

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PROLOGUE:
DRIVING IN SYRIA

I moved to Syria in 2009 to take up a senior role in an international research station outside the ancient city of Aleppo. After the quiet, ordered and spacious city of Canberra, Aleppo was a sensory blow to the head – noise and tranquility, chaos and order, beauty and squalor side by side. It terrified and bewitched me in equal measure. And when I left I was in equal parts relieved and bereft. I still grieve for what it was and what I left, particularly now that it is a country in the grip of a tragic and devastating civil war.

But this story is about driving. I was given a car as part of my employment package in Syria, a trim little Toyota Corolla that was delivered to me at the research station one Thursday afternoon.

I drove my Corolla back to my house in the suburbs of Aleppo – some 30 km drive from the research station, following the car of one of my kind Syrian friends through the bewildering maze of winding streets. When I finally reached my house, I was shaking like a leaf, and drenched with sweat. It was terrifying.

The traffic was chaotic; the other drivers on the road did not appear to be adhering to any particular road rules that I could understand. Lanes were disregarded, red lights ignored, and there was an ongoing blare of horns and voices from the drivers as well as tractors, bicycles, donkeys, trucks and handcarts apparently wandering randomly across the road. And the roads themselves were often badly marked and poorly maintained, with unexpected patches of dirt and gravel, and wheel-bending potholes.

Three months later I had completely forgotten this experience, and was comfortably and unconcernedly driving around the city. I only realised the change when I drove my European guests around the city and surrounds. I was surprised at their obvious fear and their strong reaction to the roads and traffic conditions. How could I stay so calm and unconcerned in such terrifying chaos, they exclaimed!

I realised that within three months I had adapted to the seeming chaos. This, and the fact that I managed to drive in Syria for more than a year without getting a scratch on my car, made me see that I had adapted to what was essentially a self-organising system. Although the road rules were at best sketchy and the traffic chaotic, there WAS an underlying system. As a driver I did not rely on the road rules for safety, I relied on my own senses and judgment and my awareness of, and communication with, those around me.

I found that the traffic flowed – like water or a flock of sheep. You found a gap and you flowed into it – no matter if it meant crossing two lanes. You took care not to hit those beside and in front of you and relied on those behind you not to run into you. Of course, I am not advocating it as an ideal traffic system, and there were many terrible accidents.

But what astonished me was how few accidents I did see. And I noticed the difference when I came back to Australia and started driving there again. I was afraid of the other motorists as I became aware that in many cases they were not watching out for me or aware of my presence. Their reliance on the well adhered to road rules meant that they did not feel the need to communicate with, and be aware of, other drivers (or cyclists and pedestrians for that matter – there were no donkeys thankfully). I noticed that drivers did not look me in the eye, and that I suddenly felt isolated in my car in a way I had not in Syria.

Some systems are ordered, and some are chaotic, and complex phenomena are at the interface of the two – at the "edge of chaos" (Ramalingam, 2013, p. 146). And "all complex adaptive systems … evolve to a natural state between order and chaos, a grand compromise between structure and surprise" (Kauffman, in Ramalingam, 2013, p. 146).

While I admire the well-constructed and patrolled roads and rules in Australia, I also miss the collaborative chaos of the Syrian roads and the sense of give and take I experienced. So I asked myself, could we build a relationship between an organised, maintained and regulated system like the Canberra roads, and a chaotic, collaborative, self-organising system like the roads of Aleppo (as they were back then)? And would bringing these seemingly polar-opposite and incompatible systems together create the tension to enable a new creative space for change?

What I learned from reflecting on this experience was that it was the process and the relationships between people, not the content of rules and regulations (nor the technology of the car itself), which opened the way to negotiate the conditions for the practice of driving in a seemingly chaotic system.

Similarly, this could apply to transdisciplinary research into complex societal problems. A more constructive, effective and collective research practice could be opened up by negotiating and being explicit (rather than tacit) about the actual process of the research and the relationships between the human actors, instead of relying solely on the rules.

Crutchfield puts this beautifully in the following quote:

> Can we as individuals come to appreciate the dynamic balance of order and chaos? Will our societies self-organise into a dynamic that moves beyond the least common denominator results characteristic of human groupings, towards an organisation that is appreciative of diversity, understands the role of regularity, and that is truly and constructively complex? … What lies between order and chaos? The answer now seems remarkably simple: Human innovation.
>
> (2003, p. 43)

And human innovation is at the heart of research. Can a creative tension between the ordered thinking of research disciplines (and other knowledge groups or cultures) and the chaotic world of complex self-organising systems and wicked problems help us to learn to truly innovate? And can Bateson's double bind theory that "holds that effective social rules are developed through negotiation between two incompatible extremes" (quote in Brown & Harris, 2014, p. 134) be applied to transdisciplinary research? My thesis explores these questions in the context of the untapped potential of transdisciplinary research and inquiry – in particular, focusing on research for rural development.

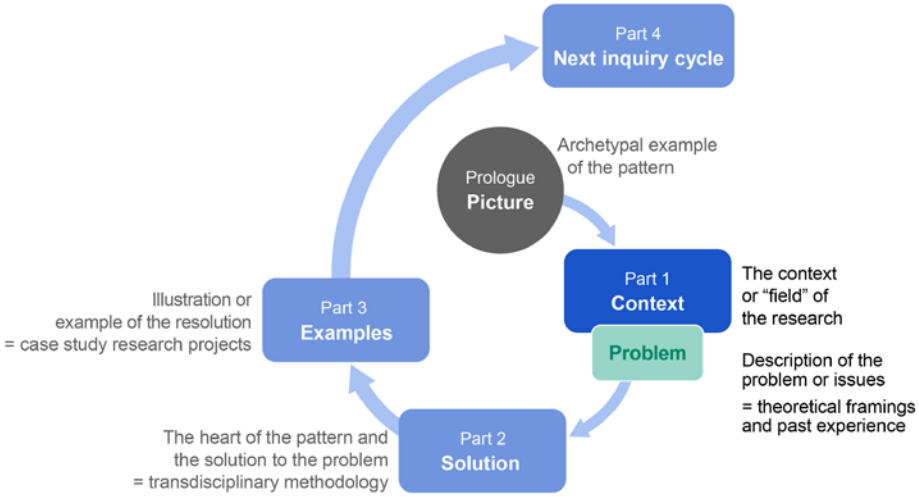
PART 1

CONTEXT AND PROBLEM

Snapshot

Part 1 of this thesis outlines the context and problem I am investigating. The two are closely linked as the problem has no meaning unless it is in its context. The introduction (Chapter 1) describes the background and structure to the thesis including the broad context and the problem. This is followed by the methodology (Chapter 2), which outlines the conceptual framework, research design and data collection methods and analysis.

Chapters 3 to 5 provide an exploration of complex systems theory and wicked problems, the broad domain of transdisciplinary thinking, and an investigation of key areas of theory to advance this practice and which I draw on for my analytical framework and methodology.



CHAPTER 1
INTRODUCTION

Until now, man has fought nature. From now on, he will fight his own nature.
(Jane Lubchenco)

Research focus

Over the past two decades or so, a new field of endeavour has sprung to life, with a plethora of journal papers, books, presentations and even research schools appearing, all of which explore, expound and investigate ideas, approaches and theory for transdisciplinary research. Intersecting with this is the growing and diverse investigation and application of complex systems theory and ideas. The concept of "wicked" problems, identified by Rittel and Weber in the 1970s, is defined by Brown et al. as "a complex issue that defies complete definition, for which there can be no final solution … but the best that can be done at the time" (2010). On a broad scale, these wicked problems include climate change adaptation and mitigation, inequity, malnutrition, poverty and so on. These problems are now being recognised as having no simple, linear or final solutions.

Transdisciplinary research approaches and dealing with wicked problems and complex systems covers a very broad context, including sustainability science, complex systems science, and initiatives such as One Health and Future Earth. It is a recognition that while science has been very successful in solving technical and physical problems, our societies continue to grapple with social problems and integrated social-ecological systems and issues in a highly complex world.

This thesis focuses on transdisciplinary research practice in international research for rural development. In particular, it is an investigation of the practice of transdisciplinary researchers working in the field of international research for rural development, tackling wicked problems such as food security, climate adaptation, malnutrition, sustainability, poverty and equity. The practice of transdisciplinary research is underpinned by the transdisciplinary skills, characteristics and traits of the individual researchers

(Augsburg, 2016), which I investigate through the subjective, lived experience of the researchers. The practice of the researchers is linked to ideas and theories through praxis, which Freire describes as "the action and reflection of men and women upon the world in order to transform it" (2005, p. 80) and "infers a joint process of inquiry and learning" (Kolb, 1984, p. 29).

The guiding aspiration for my research is to access the untapped potential of transdisciplinary research practice in complex systems. Rather than looking for new disciplines or methods, I propose that improved and more effective methodologies or approaches to research for rural development (and for transdisciplinary research more generally) can be developed through tapping into the latent possibilities of what is already there. I am investigating the idea that the lived experience of transdisciplinary researchers is not, or only partially, captured in research documentation (including proposals, reports, papers, etc.), and that there are aspects of their knowledge and practice which could be more effectively included as part of research inquiry.

I put forward four propositions about transdisciplinary research for rural development. Firstly, that research for (rural) development is inherently about complex systems and generally involves working with wicked problems. Secondly, that research for rural development is more effective when based in transdisciplinary approaches, and that a "stronger" transdisciplinary practice is possible and evolving. Thirdly, that research for rural development requires collective learning approaches that are inherent in the way all humans think (not just researchers) and that transformational change and new thinking requires questioning of held assumptions and beliefs.

The fourth proposition is the possibility of engaging Bateson's double bind theory that "holds that effective social rules are developed through negotiation between two incompatible extremes" (quote in Brown & Harris, 2014, p. 134). These seemingly incompatible extremes are a source of creativity and change and, therefore, of novel solutions. In our current framing of problems, inquiry systems and solutions, the practice of Western science is often silent on this important source of creativity and interpretation of transformational change. My thesis aim is to open up new possibilities and the latent possibilities (as formulated through human capabilities and relationships) for improved design and practice in rural research for development as well as the

broader sphere of transdisciplinary research.

My research is partly theoretical (exploring these concepts in the literature) and partly practical, drawing from the experiences of three case studies of international research in rural development, and most specifically from the experiences and perspectives of the researchers I worked with and studied. While my study is focused on rural research for development, the findings apply more generally to transdisciplinary research and sustainability science.

Research context

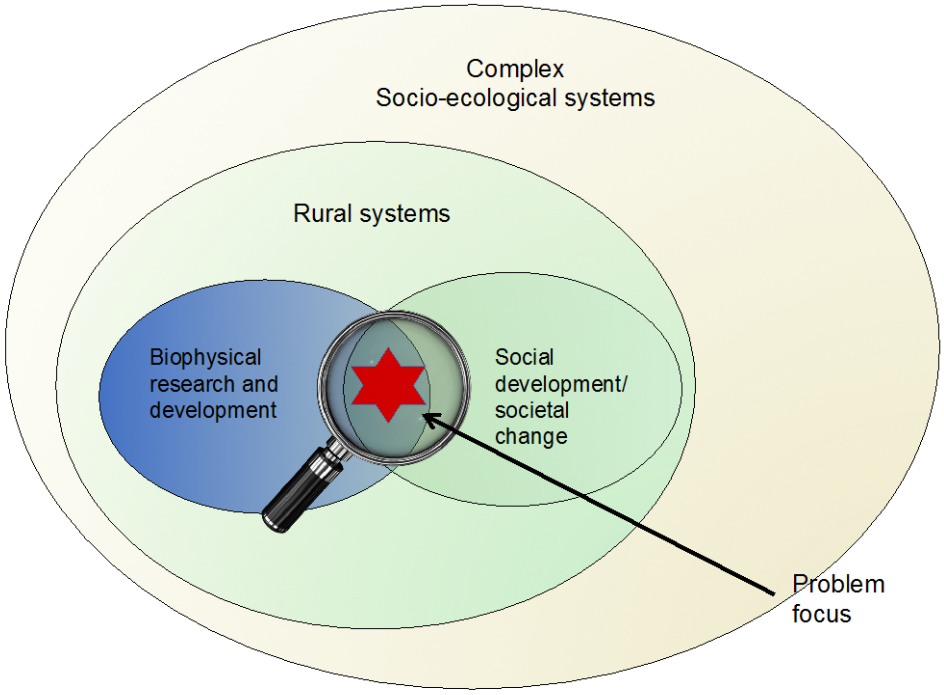


Figure 1: The context for this thesis

The context of my thesis is research for rural development, which has been the focus of my working life for many years. My early training was in agricultural science, a degree that focused on technological improvement of agriculture for increasing food and fibre production. The focus within this discipline (or group of disciplines) has shifted and changed through my working life to include such concepts as natural resource management, sustainability, farming systems, participation, social inclusion and

complex socio-agroecological systems.

For the purposes of this thesis, “research for rural development” encompasses a broad, systemic focus which goes beyond agriculture to include the social, environmental and economic systems which make up a rural system. Moseley (2003) describes some (not all) of the themes which he considers to be important in rural development, including sustainability, innovation, value-adding, entrepreneurship, community, social inclusion, accessibility, partnership and community involvement.

Moseley defines rural areas as “those with low population density containing scattered dwellings, hamlets, villages and small towns” (2003, p. 1). The distinction needs to be made here between “agriculture” defined by the Australian Macquarie Dictionary as “the cultivation of land, including crop-raising, forestry, stock-raising, etc., farming” which infers particular forms of land use, and “rural” defined by the Australian Macquarie Dictionary as “relating to, or characteristic of the country (as distinguished from towns and cities), country life, or country people” which has a much broader meaning, and encompasses a broader range of competing non-urban land uses, as well as social and economic systems. The context within which this thesis is based is also focused largely in developing countries, where rural poverty and inequity, hunger and malnutrition frequently still play a major role (although, rural poverty and inequity are still often present in developed country situations).

There is a growing awareness of the need to take a complex systems approach to management of rural systems, given the inextricable link between the social and physical (Dearing et al., 2010). We cannot extract ourselves from our physical context, nor can we consider ecology, agricultural production and the physical world without considering our impact on it, and our participation in it. Not only do we need to be able to operate at different scales (including spatial, global to local, and temporal), we also need to be able to consider a complex range of system components including environmental, economic, social and ecological (Rockström et al., 2009; Ostrom, 2009; Dearing et al., 2010).

While our scientific paradigm has been incredibly effective in improving our way of life, and solving many of our problems in many cases, it has not been enough to deal with current complex socio-biophysical problems and create effective action and social

change. Further, this paradigm has also created many of the more insidious problems that we face (Meinke and Nelson, 2010; Maxwell, 2008; Jasanoff and Wynne, 1998; Brown, 2010a; Pielke, 2010; Sarewitz, 2004; Van Kerkhoff, 2008; Funtowitz and Ravetz, 1994; Carew and Wickson, 2010; Hulme, 2010; Pohl, 2011).

According to Jane Lubchenco (in Roling, 2002), we humans are no longer faced only with the challenge of shaping our environment, but have ourselves become a major force of nature, able to transform the environment and create a new suite of anthropogenic and highly complex problems, such that the overriding problem becomes how to deal with ourselves rather than our environment (Roling, 2002). In short, "humans have become a major force of nature" (quote in Roling, 2002, p. 25).

Brown et al. (2010) draw on Rittel and Weber (1977) to describe these problems as "wicked", where the problem defies clear definition and there is no final solution, but rather multiple, partial and ongoing solutions which require the ability to step beyond traditional disciplinary and methodological boundaries, including the scientific approaches which have dominated Western thinking since the Enlightenment.

Nicolescu (2014) describes how in the 18th Century, Enlightenment science broke free of the boundaries of theology, philosophy and culture through the separation of subject and reality – that the subject who observes reality can be completely independent of that reality through a stance that has come to be called objectivity. One of the side effects of this was that humans became objects for study and exploitation. Max-Neef takes this a step further, and explains how the vast abstractions of classical economics have meant that "almost half the world's population – and more than half of the inhabitants of the Third World – turn out to be, in terms of economics, statistically "invisible" (1992, p.34). He adds, "through these abstractions, economics, instead of turning into an 'open' discipline, becomes a sort of exclusive club" (1992, p. 34).

Much of the success of nineteenth century Enlightenment science rested on dealing with problems with two or three variables with the emphasis on reducing problems to component parts (Ramalingam, 2013). Ramalingam (quoting Warren Weaver) describes these kinds of problems as those of "organised simplicity". At the other end of the scale, in the twentieth century scientists became preoccupied with system behaviour and the application of mathematics for predicting and engineering outcomes. Ramalingam calls

these problems of “disorganised complexity”. Unfortunately, most of the world’s problems do not fit in either of these categories, so Weaver proposed what he described as a “third great advance” in scientific thinking – that of “organised complexity” (Ramalingam, 2013, p. 134). From this concept of organised complexity emerges the concept of “wicked problems”. I describe this third kind of system and wicked problems in more detail in Chapter 3.

Transdisciplinary research approaches are one of the responses to complexity and wickidity of societal problems, and there is a growing body of literature which explores methodology and approaches.

Research objectives and questions

My study aims to extend the idea and practice of collective thinking and learning by combining current thinking with current practice and to open up new possibilities and the latent potential for improved transdisciplinary research practice in international research for rural development. It includes the following three objectives:

1. To investigate the practice of transdisciplinary rural research for development, through the experiences of the researchers.
2. To bring together and test a range of frameworks that can inform and guide research practice in complex transdisciplinary research.
3. To identify a common and effective methodology for strengthening the practice of transdisciplinarity.

In this thesis, I pose the following research questions:

1. What frameworks and concepts may be useful to facilitate more effective transdisciplinary practice that enables synergies from difference?
2. How do researchers experience their own transdisciplinary practice in tackling wicked problems?
3. Can there be a unifying, connecting and effective methodology for strengthening transdisciplinary research practice?

I address these questions through three case study projects in international research for rural development and through an exploration of theory.

Thesis structure

I have structured my research (and this thesis) according to a conceptual framework that is based on the "pattern language" format approach of the architect Christopher Alexander (1977). Alexander describes a format for each pattern that consists of five steps. He starts with a picture showing an archetypal example of the pattern. The second step is the context for the pattern, which explains how it completes or contributes to larger patterns. Step three is the description of the problem, followed by the solution in step four. He describes the solution as "the heart of the pattern – which describes the field of physical and social relationships which are required to solve the stated problem, in the stated context" (Alexander et al. 1977, p. xi). Step five is the illustration or example of the solution.

The pattern language allows me to situate and describe my research in its context, and provides a structure for the thesis which reflects the web of issues and the exploration of the problem, the solution, followed by the illustration, which is the examples or case studies through which I test the solution. The illustration leads to a new picture, and a new cycle of inquiry starting with a renewed view of the context and so on. This thesis is structured according to the pattern language, which is not a usual or traditional approach or structure for a thesis. I have chosen this approach as a response to the challenges of working in complex systems, and to test and apply a potentially useful approach for transdisciplinary inquiry.

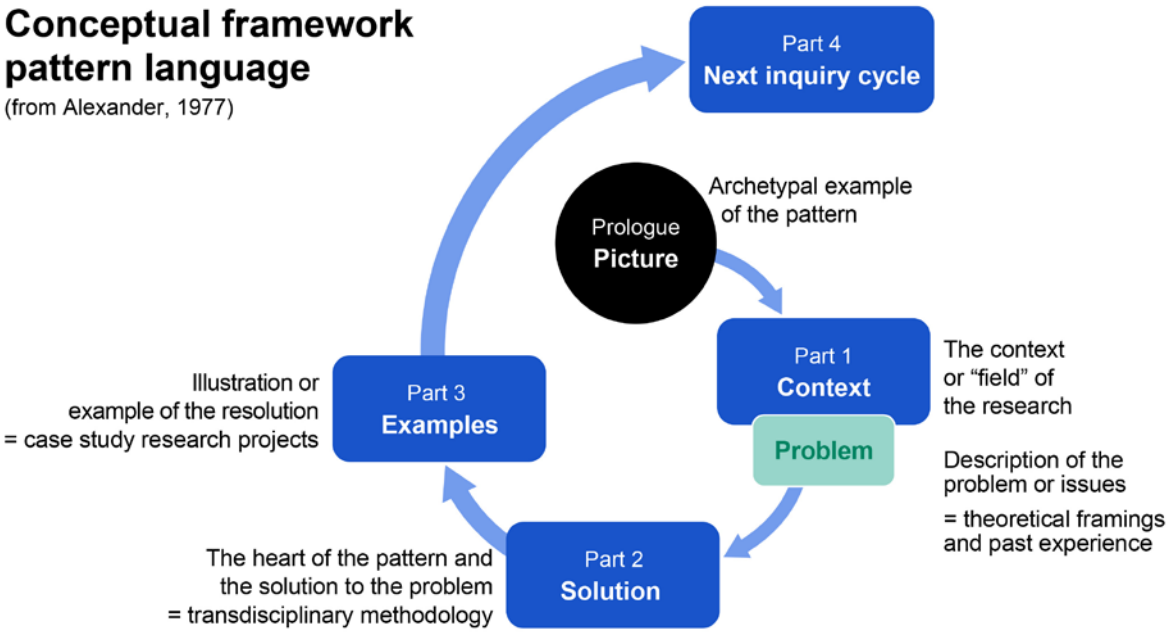


Figure 2: The inquiry cycle and the pattern language

The picture: Prologue

The prologue provides a brief story or parable "Driving in Syria" to provide an illustration or snapshot of the overall inquiry.

Context and problem: Part 1

Part 1 includes the context as well as the problem, as the two are closely intertwined. **Chapter 1** outlines the context of the thesis, and its structure. **Chapter 2** outlines the thesis research methodology, including the conceptual framework, analytical framework, data collection methods and approach. I have deliberately placed the methodology here for two reasons. Firstly to provide an explanation and roadmap of the structure of the thesis and the inquiry design, and secondly because the following chapters are more than literature review chapter, but are part of the theory synthesis of the thesis (which is a significant focus in this work) and the adaptive approach which I outline in more detail in Chapter 2.

Chapters 3, 4 and 5 document the theory synthesis, which includes the review of the various strands of literature which have been brought together to form a key component

of the synthesis which is my analytical framework, and forms the basis (along with the practical learnings from the case studies and my own experience) for the transdisciplinary methodology that I am proposing. **Chapter 3** outlines key concepts in complexity science, systems thinking and wicked problems. This includes a broad overview of the different conceptions and evolution of complexity and systems thinking, focusing in on the concept of organised complexity and the dynamics of self-organising systems, and a framework and dialogical tool for mapping out the context of a wicked problem.

Chapter 4 provides an overview of current thinking in the transdisciplinary literature as it shifts thinking away from the positivist ideas of the Enlightenment, and brings back together the compartmentalised knowledge of the disciplines and non-disciplines or practical, lived experience. The literature spans various conceptions, definitions and experiences of transdisciplinary research. It highlights questions about philosophical underpinning, methodological approaches and principles, and challenges and critiques various approaches, principles and quality criteria as well as investigating current ideas of transdisciplinary research practice.

Chapter 5 brings together the various strands of collective and social learning literature. In this chapter, I investigate key themes in transdisciplinary thinking that emerge from Chapter 4, including the logic of the included middle (including paradox and creative tension), the need for recursiveness, collective and evolutionary learning, and reflection and reflexivity. Posing learning as a fundamental process in research and problem-solving more generally, this chapter begins with the foundations of the Pragmatists. In particular, the review of literature focuses on those learning processes that set the scene for transformational change and new thinking, rather than incremental learning within set assumptions and beliefs. In particular, it includes a look at the challenges and opportunities posed by clashes in competing worldviews, and the creative tension that arises out of seeming paradoxes or dichotomies. In addition, it lays out the concepts of the seven lenses or doorways for collective thinking as a means of bringing together different worldviews, and a more holistic view of complex socio-ecological problems.

Solution: Part 2

Part 2 forms the core of this thesis and is the pivot around which the iterative approach to theory formation and data analysis and interpretation revolve. It is the solution or step 3 in Alexander's pattern language approach. In **Chapter 6**, I propose a methodology for transdisciplinary research practice, consisting of five principles each with a set of provisional patterns that I adopt as analytical tools. These principles are derived from the theoretical foundations and synthesis in **Part 1**, combined in an iterative recursive process with the practical lived experience of the researchers in the three case study transdisciplinary research projects which I outline in **Part 3**.

Illustration: Part 3

Part 3 is the illustration of the solution. This is the findings and analysis from each of the three case study projects. **Chapter 7** provides a narrative for each of the three research projects, and details my learnings and insights and the way in which they each informed (and were informed by) the parallel theory exploration and synthesis.

In **Chapters 8 to 11,** I provide a more detailed analysis of Case Study 3, using the provisional patterns as analytical tools for each principle. Case Study 3 is studied in the greatest depth and is the project to which I had the greatest access.

Beginning a new inquiry cycle: Part 4

Part 4 includes the discussion and conclusions, the end of the thesis inquiry cycle and the beginning of a new iterative inquiry cycle. In **Chapter 12**, I synthesise key learnings and conclusions from Parts 1, 2 and 3, and lay the foundation for a new inquiry cycle in Chapter 13. **Chapter 13** includes a new picture (that of iterative and recursive inquiry and learning), an expanded and evolving context (moving beyond international research for rural development to the broader context of transdisciplinarity) and a new set of challenges for enabling transdisciplinarity that emerge from the previous inquiry.

CHAPTER 2
METHODOLOGY

> Not everything that can be counted counts, and not everything that counts can be counted.
> (Albert Einstein)

This study focuses on complex transdisciplinary systems, in particular in international rural research for development. It requires a detailed examination of social interactions; hence I have chosen a largely qualitative approach. I have outlined my methods according to Patton's strategic research framework, which includes the following three categories or strands:

1. research design
2. data collection and fieldwork methods
3. analysis strategies.

(Patton, 2002, p. 39)

My philosophical framing for this thesis inquiry combines constructivism with elements of critical theory and a pragmatist perspective. This includes adopting a relational ontology and a largely transactional and subjectivist epistemology (Denzin & Lincoln, 2011, p. 92). Together, these imply a social and experiential construction of meaning (leading to my application of interactive, qualitative, field-based methods), and that entities are interpreted through their relationships rather than their essential characteristics (supporting my emphasis on analytical frameworks that highlight such relationships). In addition, meaning making is a continuous and ongoing process, and multiple realities can exist, depending on the individual (Ansell, 2011; Denzin & Lincoln, 2011; Crotty, 1998), which is embodied in my adaptive, iterative research design. This approach also recognises the power structures and asymmetries which sit behind knowledge creation and sharing. From the pragmatists, I adopt the recursive, reflective approach and the need to build direct links between theory and praxis and vice versa.

Research Design: conceptual framework

My research design is transdisciplinary, and includes a conceptual framework based on the pattern language of Alexander (1977) also drawing on Layder's adaptive theory approach (2005) and Patton's developmental inquiry (2011). This provides me with an iterative approach where theory synthesis and data analysis inform each other iteratively. I also draw on appreciative inquiry (Hammond & Royal, 1998; Cooperrider, 2003) as a means to focus on possibilities and potential rather than focusing the inquiry process on deficiency or a problem to be corrected. The point of this is to ensure that the field of inquiry remains open to the new and the positive, and appreciating and valuing what is, envisioning what might be, dialoguing what should be, and innovating what will be. In addition, I draw on concepts from ethnographic research, and the need for an in-depth examination of the research practice in the case studies, including highly descriptive and narrative approaches.

Alexander developed the pattern language after grappling with the problems of complexity in environmental design. He argues that humans have developed archetypal designs (or patterns) as a response to recurrent problems, and that these designs satisfy the fundamental human need for "safety, comfort and a good view" (Turner, 1996). The patterns are a description of problems that repeat themselves, and then describe the core of the solution to the problem. The patterns (and problems and solutions) repeat endlessly, without the same outcome ever emerging twice. In this way, a city is a series of interlinked and interrelated patterns rather than a hierarchy.

Alexander describes a format for each pattern that consists of five steps. He starts with a picture showing an archetypal example of the pattern. The second step is the context for the pattern, which explains how it completes or contributes to larger patterns. Step three is the description of the problem followed by the solution in step four. He describes the solution as "the heart of the pattern – which describes the field of physical and social relationships which are required to solve the stated problem, in the stated context" (Alexander et al., 1977, p. xi). Step five is the illustration or example of the solution. Alexander saw two essential reasons for using the pattern language format. Firstly, because the patterns are all interconnected to form a language with an infinite number of combinations, and secondly, so that the problem and solution remain interlinked

since each is the flip side of the other, even though every solution is unique (1977).

Although the format for the pattern language was originally conceived for the design of cities, buildings and other spaces, Brown and Harris have adopted it as a tool "for the collective mind in the sense that it addresses the whole of an issue in a format that draws together the thinking of all those involved" (2014, p. 62). I have used it here to provide a framework for my thesis structure, and a way in which to situate my research, as well as a possible framework for the transdisciplinary research I am investigating.

In the same way that Alexander talks about combinations of patterns to make buildings and towns and the shared spaces within them, I see the concept of the pattern language as a way to make "spaces" and a "language" for transdisciplinary research for development in dealing with complex systems. As with the environmental design, these "spaces" need to provide "safety, comfort and a good view" in the face of the unknowns and uncertainties posed by crossing disciplinary and other knowledge boundaries, and dealing with highly complex, intractable problems (which I am calling "wicked").

I have chosen a modified version of the pattern language for two reasons. Firstly, it provides an iterative or recursive approach, which aligns well with Layder's adaptive theory approach. Layder describes the adaptive theory approach as being "meant to convey that the theory both adapts to, or is shaped by, incoming evidence while the data itself is simultaneously filtered through, and is thus adapted by, the prior theoretical materials (frameworks, concepts, ideas)" (2005, p. 5).

Secondly, the focus on patterns is important and "formalizing and quantifying the notion of pattern and the process of pattern discovery go right to the heart of scientific practice" (Crutchfield, 2003, p. 41). In the context of design of cities and homes, Alexander describes patterns as describing "a problem which occurs over and over again in our environment" (Alexander, 1977, p. x). Just as Alexander proposes a set of universal repeating patterns in physical design, I explore whether it is possible to identify a series of provisionally universal patterns to create a shared language between widely differing worldviews and approaches, to assist in the process of finding a series of ongoing solutions to wicked problems in transdisciplinary research inquiry.

I use the pattern language to help identify patterns in my research, as well as to test it as

a useful tool to find recurring "pattern sets" in the transdisciplinary research I am studying, as an alternative to trying to reduce the complexity of the context and problems under study. In addition, the pattern language inquiry process is cyclical, so that each solution allows for the emergence of a new round of problems and solutions.

Both my thesis study and the study subject are complex and transdisciplinary. My study is transdisciplinary in the sense that I am drawing on a broad spectrum of knowledge and experience, and communities of practice. I draw on my own personal and professional experience as an agricultural researcher, and in program management, research design, research for development and communication practice.

My research has been highly iterative. Having outlined the context of my research, I looked at the theory synthesis (literature) before proceeding to the examples (data collection). From here, the data informed a further investigation of the literature and theory synthesis, which provided me with the analytical tools to analyse the data. This in turn informed another round of theory synthesis from which emerged the five principles of transdisciplinarity. The next iteration was testing the principles against the case study data.

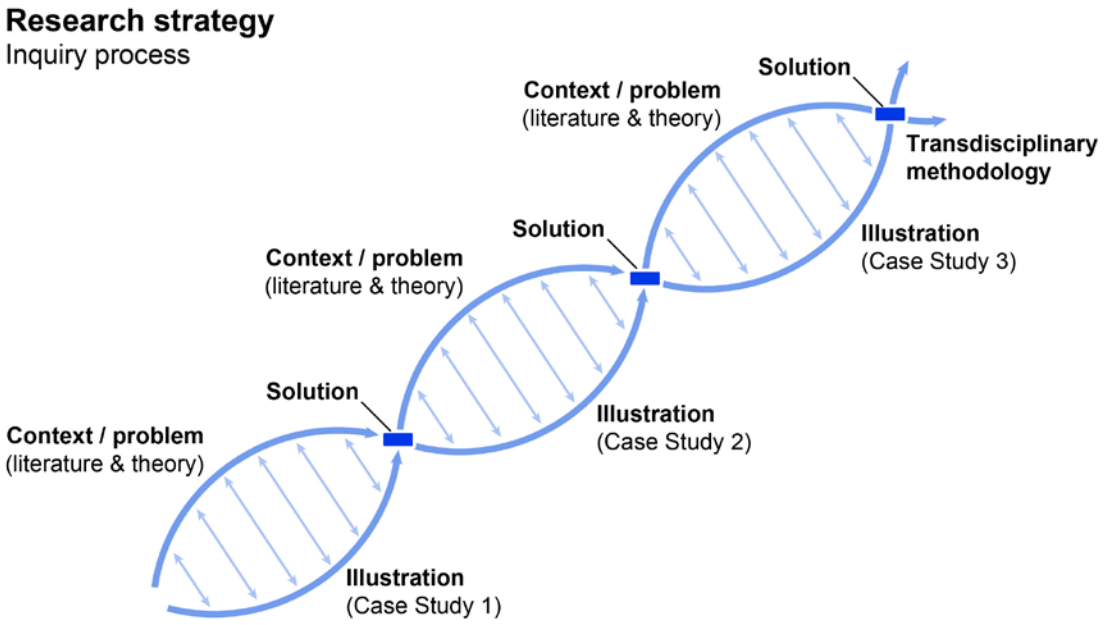


Figure 3: An iterative and recursive research strategy, with theory and data informing each other

The second part of the research strategy deals with the need for an in-depth examination of the research practice including highly descriptive and narrative approaches. In this instance, I am drawing on the concepts presented by both Geertz (1973) and Patton (2002) of ethnographic research, in particular the need for "thick description".

Finally, my research can be classified as both adaptive theory and developmental evaluation (Patton, 2011), based on the need for an iterative, evaluative and reflective approach. Patton poses the concept of developmental evaluation as a combination of formative (focused on improving the design) and summative evaluation (focused on making a judgment about the value, validity and effectiveness of the project or program) (2011, p. 2). He sees developmental evaluation approaches as particularly applicable to situations of high complexity where non-linearity, emergence, dynamical systems, adaptiveness, uncertainty and co-evolutionary processes dominate (2011, p. 7).

Research focus/needs	Design approach	Theorists
Complex systems approach dealing with wicked problems Both the study and the study subject are complex and transdisciplinary	Open transdisciplinary inquiry Appreciative inquiry Pattern language	Brown (2010) Alexander (1977) Cooperrider (2003)
In-depth examination of research practice – qualitative approach	Ethnographic – thick description	Patton (2002) Geertz (1973)
Iterative, evaluative and reflective approach where theory and data inform each other	Adaptive theory Developmental evaluation Appreciative inquiry	Layder (2005) Patton (2011) Cooperrider (2003)

Table 1: Thesis research design strategy, linking research needs, design approaches and theorists

Data collection and fieldwork methods

My research included three case study research projects, where all three projects were tackling a wicked problem in the domain of international research for rural development; they identify themselves as transdisciplinary teams using transdisciplinary approaches; and they include multiple countries, organisations and disciplines. All three focus on aspects of food security and smallholder livelihood improvement in developing countries. In addition, the project teams were prepared to accept my

presence, and who were at least to some extent aware of issues of complexity and the challenges of transdisciplinarity, and were motivated to strive for strengthening transdisciplinarity in some form. There was also a highly practical aspect – the projects needed to be able to provide me with a useful role and some operating and travel funds to participate.

Projects were selected on the basis that they were all of 3 to 5 years duration, of sufficient scale to include at least three collaborating countries and more than 20 researchers, and that they focused on a wicked problem. All three were funded through the Australian Aid program (though not necessarily through the same funding agency).

A brief summary of each case study is included in **Table 2**. The research teams are generally large, but vary not only between case studies, but over time as participants enter and leave the research team. In each case, my role within the project varied, but in each case I was a team member in some form at particular stages.

Case study	Geographical focus	issue focus	My role
Case study 1	Two countries, regional focus (Sri Lanka, India)	Climate forecasting and adaptation for food security	Initially social scientist, then varied – finally observer
Case study 2	2 countries, regional focus (Tanzania, Zambia)	Livestock livelihoods for nutrition and gender empowerment	Communications consultant, scoping team and observer
Case study 3	4 countries, agricultural system focus (India, Bangladesh, Lao PDR, Cambodia)	Adapting rice systems for food security at multiple scales	Informal evaluation, mid-term review participant and observer

Table 2: Summary description of the three case studies

Based on the adaptive theory approach to the thesis study, my investigation of the first two case studies was largely formative, and I used an iterative and evolving approach where data and theory informed each other. The third case study provided a more mature project (in terms of lifecycle) that allowed me to test the ideas from cases study 1 and 2. In addition, the progression of three case studies provided me with the opportunity to refine and evolve my inquiry process. The findings chapters therefore, focus largely on the insights from Case Study 3, with a series of contrasting and enriching examples and insights from the other two case studies.

Given the design strategies outlined above, I have adopted a multi-method approach as outlined in **Table 3** as a means of maximising depth and being inclusive of different viewpoints, and in the interest of achieving Geertz's "thick description" and according to Layder's advice, that "it is important make as many investigative 'cuts' into the data as feasible …" (2013, p.71).

Methods	Vehicles for data collection
In-depth unstructured – semi-structured interviews	Interviews with key project participants
Participant observation	Observations of project interactions
Literature critiques	Project documents (including plans, correspondence, reviews, reports)
Participant review	Feedback from key participants
Research diaries	My personal reflective research diary

Table 3: Multi-method research approaches and the vehicles for data collection

The data collection included the following:

Methods	Vehicles for data collection	Total number
In-depth unstructured interviews	Interviews with key project participants	49 people interviewed 72 interviews in total
Participant observation	Observations of project interactions	12 project meetings 8 field visits/data gathering events
Document review	project documents (including plans, correspondence, reviews, reports)	>40 documents reviewed
Research diaries	My personal reflective research diary	
Field visits	Accompanying team members in country	13 in-country field visits (total of 112 days) Total number of countries: 6

Table 4: Summary of data collected for this thesis study

Semi-structured interviews

Semi- to un-structured interviews were conducted with key project participants from each case study. These formed the primary data for analysis purposes. Samples were drawn from those directly involved in immediate research teams. However, team

boundaries are often somewhat blurred as team members move in and out of the project as required, and a number are part of a secondary group of people that the project works with and through.

The interviews included interviews with researchers and other participants from a range of partner countries though predominantly with Australian scientists. Although I did conduct interviews with a number of country partner scientists, many were hesitant to do so for a number of reasons. These include lack of English-language skills and risk aversion particularly in countries with less open political systems. For them, there are a number of inherent risks in participating in frank and open interviews with another researcher. Variable English-language skills and my lack of fluency in any of their languages made communication on these complex issues difficult to near impossible. In addition, the kind of interviews I conducted required a level of trust and openness and a connection with me. This was possible in all three of the case studies, though interestingly; the in-country scientists I interviewed were predominantly from Sri Lanka, India and Tanzania rather than from Lao PDR or Cambodia. In addition, interviewing non-research participants was only patchy and not easy to achieve. Generally, I was not encouraged to interact with non-research participants, and in many cases, there were significant barriers to this as outlined above. In Case Study 1 and 2, I interviewed a limited number of non-research participants, but in Case Study 3 this was not possible.

The interview protocols (or the kind of question groupings I used) changed between Case Study 1 and the other two case studies. Case Study 1 was a pilot study, and served to clarify my interview approach, and the kind of prompts and tools I used. At the beginning, I included a stakeholder mapping exercise, which I did not do in the later interviews.

In case studies 2 and 3, I focused on a more narrative-style approach, allowing the participants to tell the story of their involvement in the project, but still picking up on experience (both before and during the project), observations and insights and expectations. Case Study 3 in particular was quite advanced by the time I became involved, so participants were able to provide me with a more comprehensive narrative as well as reflections.

Participant observations

I took participant observation notes during each of the project activities and events I was involved with. These notes related to my own observations and experiences during my participation and interaction with the project team and with project activities. The kind of project activities I participated in were generally dictated by the project leaders and by funding availability as discussed in the previous section.

Project documentation

In addition to the interviews (primary data) and the participant observations (secondary data) I also analysed project documentation where it was supplied to me. This included project proposals, variations, annual reports, other reports, review documents, and published papers.

Meetings	•Team meetings, planning sessions, feedback and reporting •Scoping study •Training and information sharing
Field visits, data gathering	•Scoping – informal early "fact-finding" •Baseline study – household interviews •Mid-term review field trip
Skype, phone, email	•Team meetings by skype or phone hookup •Interviews and informal interactions with project team members •Email exchanges both formal and informal
Informal interactions, day-to-day activities	•Observations and interactions in participants offices and workplaces •Periods spent in-country (up to 2 months)

Table 5: Indicative project activities studied

Analysis strategies

I have undertaken qualitative data analysis by organising and reporting the findings through narrative development, emergent themes, orienting concepts and pattern recognition. In addition, I have used the adaptive theory approach adapted from Layder (2005) to bring together deductive or theory-testing processes (with theory guiding

data), and inductive or theory-generating processes (with theory emerging from data).

Orienting concepts (Patton, 2002) have been identified as a means to guide the direction of data interpretation and analysis and to allow for these concepts to develop over the course of the analysis process. In addition, I have used a narrative development approach, via individual, project and other narratives and narrative themes emerging from the data. This allows for key themes to emerge from the data (Jupp, 2006).

Organising and reporting descriptive findings	Interpretation
• Narrative • Thematic • Case study focus (at different levels) • Sensitising concepts (from prior theory and experience) • Thick description (rich detailed and concrete descriptions of people and places)	• Emergent themes • Pattern recognition • Iterative approach • Deductive, theory-testing as well as inductive theory-generating approaches

Table 6: Analysis strategies

From this analysis, the five principles for strong transdisciplinary research and the five pattern sets (which I outline in Chapter 6) emerge and are then used to analyse and interpret data from Case Study 3 (Chapters 8-11).

CHAPTER 3
COMPLEXITY, WICKIDITY AND DEVELOPMENT

When we try to boil down complex systems, the key finding is that they cannot be boiled down
(Phil Teare, in Ramalingam 2013)

If you try and take a cat apart to see how it works, the first thing you have on your hands is a non-working cat
(Douglas Adams, 1991)

This chapter (the first of three literature review chapters) explores the literature on complexity science, complex systems and wicked problems. This includes a broad overview of the different conceptions and evolution of complexity and systems thinking, focusing in on the concept of organised complexity and the dynamics of self-organising systems. It also explores the literature on wicked problems, and develops a wicked problem "pattern set" for investigating the research context for wicked problems.

Conceptions of complex systems

In rural development (or agro-ecological or agri-food systems) as described by Conway (1987, 2010) and Thompson and Scoones (2009), the focus is on uncertainty, complexity and diversity of ecological, economic and social processes and where physical and social systems are inextricably intertwined. Key characteristics of complex systems include emergence, non-linear dynamics and uncertainty, positive feedback, structural coupling, self-organisation (or auto-poiesis), messiness, diversity and the dynamic nature of knowledge and learning (Fenwick et al., 2011). There is a growing movement in the sciences towards complex adaptive systems as new ways to think about and tackle "thorny problems of research, policy and practice" in development (Ramalingam, 2013, p. Xvi).

Checkland distinguishes between "hard" and "soft" systems – stating that as early as 1954 the only kind of systems thinking being considered was a mathematically-based general theory of systems which has not succeeded in representing the complexity of the world and its problems and unifying the sciences (2005, p. A3). He describes classic

systems engineering (“hard systems”) – in which a system with a particular objective is identified and “engineered” to meet that objective. Similarly, Ramalingam highlights the ongoing tendency and bias towards “treating the world as a simple predictable place” where systems can be engineered and outcomes can be predicted. He is speaking particularly about the delivery of development aid, where there is an overwhelming push for simplification, standardisation and predictability at the expense of relevance and appropriateness (2013). Shutt argues that focusing on measurable units and things that can be counted misses the point in difficult to manage change in complex transformational change initiatives, where there is unpredictability, complexity, diversity and dynamism (2015, p. 69-70).

The advent of chaos theory in the 1970s was enthusiastically received by the science community, and marked a shift from the dominance of linear thinking and modelling and towards a more heterogeneous view of the world. But despite the shift away from “high modernity” and its focus on social engineering, planning, predictability and the belief in simple cause-effect relationships and linearity, the belief in these ideas still lingers in science and planning (Nowotny et al., 2001).

Checkland points out that in matters involving humans, finding consistent and pursuable objectives is exceedingly difficult. He gives the example of the Common Agricultural Policy (CAP) in the then European Economic Community (now incorporated into the European Union) which had three conflicting objectives (increase agricultural productivity, protect agricultural industry jobs, and provide the best possible service to the customer) (Checkland, 2005, p. A6), which is a classic example of a wicked problem.

In his 1948 paper on complex systems, Weaver talked about the shift in science from dealing with organised simplicity (dealing with two or three variables) to dealing with an astronomical number of variables – in systems that he called disorganised complexity. He then highlighted what he called the “problems of the middle region” (Weaver, 1948 in Byrne & Callaghan, 2014) which show organised features and which Weaver referred to as “organised complexity” and encompassed a large number of real-world problems (Ramalingam, 2013, p. 134). Organised complexity corresponds to the concept of a self-organising system.

Other organised complexity principles or characteristics include emergence and nested systems, uncertainty, non-linear dynamics, internal diversity, perturbation and feedback loops, self-organisation (as an effect of emergence) and the tension of order and disorder (Fenwick, 2012).

These systems of organised complexity are characterised by emergent properties, which cannot be observed in the component parts but require a study of relationships (Ramalingam, 2013, p. 144). Examples of this include the flocking behaviour of birds, cloud formations and the social behaviour of insects. In the case of organised complexity, however, these emergent properties cannot be predicted consistently as with systems of organised simplicity or disorganised complexity. The nature of the system and the nature of its elements and their relationships emerge recursively through interactions that enable continuous change and self-organisation. This includes the human and non-human "elements" of the system (Fenwick, 2012). This means that actors and objects cannot or should not be isolated from their context or be seen as having clear boundaries between them. Instead, it is more useful to see a series of nested systems within which actors and objects are situated.

In describing approaches to agricultural resource management research, policy and practice, Pant talks about three schools of systems thinking including research into the systemic world (described by Checkland as "hard systems" research), systems research into the messy world (or Checkland's "soft systems" research), and critical systems research into an unjust world (2014, p. 342).

Ramalingam examines complexity research through the lenses of systems, behaviours, networks and dynamics (p. xvii, 2013). Complex systems share attributes and behaviours that cannot be explained by studying the parts. In other words, analysing the component parts will not yield an understanding of the whole. In this case, the sum is greater than, and different to, the parts. It is the relationships between the components and their relationship to the whole that matters (Westley et al., 2006) though this is not definitive either, as these relationships shift and change in a self-organising system. Linearity and predictability are not helpful (Vincent, 2012; Fenwick, 2012; Bastardas-Boada, 2014).

Complexity as practice

Alhadeff-Jones (2008) in his review of complexity science suggests the study and application of complexity as a means of challenging the ways in which researchers interpret the world, and to critique traditional modes of organising knowledge, including through transdisciplinarity. In particular, he suggests the generation of knowledge in a series of cycles, rather than a linear accumulation. In addition, the growing expectation that research and other practitioners collaborate closely with others (including researchers, practitioners and other participants) is contributing significantly to the complexity of everyday practice both within and outside research (Fenwick, 2012). This complexity includes the incorporation of multiple worldviews and diverse disciplinary approaches. The resulting disconnects among different knowledge cultures and conflicting community of practice boundaries serve to deepen the level of complexity.

New approaches to understanding, generating and acting on knowledge are required to tackle problems in such a world. The diversity of thinking and writing on complexity science is a good example of this. A review of the literature on complexity science or complex systems science, highlights the diverse nature of the field and the various different conceptions of what constitutes complex systems science or studies (Vincent, 2012, p. 5).

In his description of soft systems, Checkland talks about the shift to a learning system, so that the word “system” no longer applies to the world but is applied to the process of our dealing with the world. Fenwick reinforces this view from the education research literature, that complex systems are learning systems (2012, p. 142). This highlights a fundamental difference between hard and soft systems thinking. Checkland advocates a shift away from thinking about systems that can be engineered, towards constructing a learning system that can be used to view and navigate complexity and confusion. Similarly, Ramalingam emphasises that applying complexity science to real-world problems is about the mindsets we employ rather than focusing on the potential solutions (2013, p. Xvii). There are no easy or simple answers to these problems; rather we need better ways of thinking about them.

Because there are so many interactions and relationships happening and emerging,

uncertainty and surprise is inevitable but at the same time is the source of many new possibilities, sources of change and solutions (Fenwick, 2012). These changes are intensified and accelerated by positive (and negative) feedback loops, emphasising the recursive nature of organised complexity.

Importantly, there is a constant tension between what Fenwick describes as disordering dynamics and ordering patterns (2012, p. 147). This is also described as the "edge of chaos" or a state between order and chaos, where the ability of the system to learn and change is at its peak (Ramalingam, 2013, p. 146). Fenwick et al. quotes Ilya Prigogine's description of the use of complexity science as a means to overcome the false dichotomy between determinism (predictability) and a state of chaos (p. 19).

Crutchfield quotes Nabokov on the origins of creativity as being a:

> delicate meeting place between imagination and knowledge, a point, arrived at by diminishing large things and enlarging small things that is intrinsically artistic. (Nabokov in Crutchfield, 2003, p. 11)

In transdisciplinary research practice (discussed further in chapter 4), a focus on complexity and its concepts has been shown to assist participants not to prioritise consensus and agreement, but rather to seek and engage with greater diversity in the research system that they are part of (Fenwick, 2012). Instead, diversity lays open a wider range of options and avenues for constructive change and even transformation – allowing for synergy among the parts. This requires a high level of trust and tolerance of ambiguity among participants.

Fenwick and cowriters emphasise the importance of focusing on socio-material approaches, rather than creating and maintaining a false divide between the social/human and the material/natural reality. They propose this as a means to provide the resources needed to systematically look at both patterns and unpredictability within the system. Writing from the perspective of learning systems and pedagogy, she emphasises the need to look more broadly than the individual human subject and avoid a false separation between the social and material reality, rather than emphasising the interactions and relatedness as part of an organised complex system (Fenwick, 2012; Fenwick & Landri, 2012; Fenwick et al., 2011).

Westley et al. say “to understand social innovation we must see the world in all its complexity” (2006, loc 207). They go on to say that machine metaphors fall far short of representing the living aspects of the world and our work. Complexity science represents life as it is – unpredictable, emergent, evolving and adaptable.

Pinning down the wicked problem

Related to these ideas of organised complexity, complex systems and complex adaptive systems, is the concept of wicked problems. These are problems of the real world, which go beyond complexity, for which there are no clear and final solutions and for which there is no single clear problem statement.

Head describes wicked problems as those “inherently resistant to a clear statement of a problem and resistant to a clear and agreed solution” (p. 102, 2008). One of the key difficulties in research for rural development in complex systems (and in the broader sphere of social change and sustainability science) is clear problem definition. This is challenging in a complex systems context, but even more so in a wicked problems context. Brown et al. provide a succinct definition of wicked problems.

> A wicked problem is a complex issue that defies complete definition, for which there can be no final solution, since any resolution generates further issues, and where solutions are not true or false or good or bad, but the best that can be done at the time. (2010, p. 4)

They add that these wicked problems are intertwined with the society in which they occur and that they generally require social change as part of any resolution process. From a research or inquiry perspective, they require new approaches and “the full range of investigative avenues” (Brown et al., 2010, p. 4).

There is considerable literature, debate and even controversy around wicked problems, what they mean, how to define them, how to tackle them and even whether they exist. I use the term “wicked” here not because I see it as the definitive term, but in a practical sense, as it is the term most widely used in the literature to describe this phenomenon, and to distinguish it from complex. However, a number of other terms and descriptions can and have been used, including “messy”, “controversial”, or “ill-structured”.

The term “wicked problem” was originally coined by Rittel and Weber (while looking at the kind of problems faced by urban planners) who pointed out that “[one] of the most intractable problems is that of defining problems … and of locating problems … and equally intractable, is the problem of identifying actions that might effectively narrow the gap between what-is and what-ought-to-be” (p. 159, 1973). For them, nearly all public policy issues are wicked, and they developed a list of ten distinguishing properties for wicked problems:

1. There is no definitive formulation for a wicked problem.
2. Wicked problems have no stopping rule (i.e. no final and ultimate solution).
3. Solutions to wicked problems are not true-false, but good-bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a “one-shot” operation; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution.
10. The planner has no right to be wrong. (There is no seeking for truth or refutation of hypotheses, and there are consequences for the actions that are generated.) (Rittel & Weber, 1973)

The point of talking about, and acknowledging, the reality of wicked problems is not an avoidance of difficult problems, but rather it opens up a whole new world of possibilities where causality, predictability and linearity give way to a world in which we can “embrace uncertainty, welcome paradoxes and accept ignorance as the source of new ideas” (Brown, p. 3, 2011). I discuss paradox and anti-dualism in Chapter 5 as an important source of creativity and innovation, but here it is worth mentioning that in the case of a wicked problem, the paradox is that the source of the problem is also the basis for its resolution (Brown, p. 63, 2010). In fact, these problems are characteristically

paradoxical, and general involve diverse ethical positions, worldviews, and ways of constructing knowledge.

In the second of their ten properties of wicked problems, Rittel and Weber state, “every formulation of the wicked problem corresponds to a statement of the solution and vice versa” (1972, p. 392). In this case, understanding the problem is the flip side of one of the possible solutions. Rittel and Weber (1973) and Klein (2004a) highlight a growing realisation that disciplinary orientations on knowledge are insufficient, and that knowledge production in disciplinary research is less able to solve societal problems (Hoffmann-Riem et al., 2008). Rittel is much more specific when he says, “the knowledge needed in a planning problem is not concentrated in any single head; for wicked problems, there are no specialists” (1972, p. 394).

Brown et al. also highlight this, emphasising the different ways of knowledge generation for five “knowledge cultures” in Western society. Individual, local, specialist, organisational and holistic knowledge cultures all have different ways of gathering, interpreting and understanding evidence and generating knowledge (2010).

Characteristic	Tame problems	Wicked problems
Problem formulation	The problem can be clearly written down. The problem can be stated as a gap between what is and what ought to be. There is easy agreement about the problem definition.	The problem is difficult to define. Many possible explanations may exist. Individuals perceive the issue differently. Depending on the explanation, the solution takes on a different form.
Testability	Potential solutions can be tested as either correct or false.	There is no single set of criteria for whether solutions are right or wrong; they can only be more or less acceptable relative to each other.
Finality	Problems have a clear solution and end point.	There is always room for more improvement and potential consequences may continue indefinitely.
Level of analysis	It is possible to bound the problem and identify its root cause. There is no need to argue about the level at which to intervene; the parts can be easily separated from the whole.	Every problem can be considered a symptom of another problem. There is no identifiable root cause and it is not possible to be sure of the appropriate level at which to intervene; one cannot easily separate parts from the whole.
Replicability	The problem may repeat itself many times; applying formulaic responses will produce predictable results	Every problem is essentially unique; formulae are of limited value.
Reproducibility	Solutions can be trialled and excluded until the correct solution is found.	Each problem is a one-shot operation. Once a solution is attempted, you cannot undo what you have already done.

Table 7: A classification of "tame" versus "wicked" problem characteristics (Ramalingam et al., 2014)

As summarised in Table 7, Ramalingam et al. (2014) compare characteristics of "tame" versus "wicked" problems which highlights why wicked problems cannot be effectively tackled using single disciplinary approaches.

Approaches for tackling wicked problems

Just being able to define or recognise a wicked problem is, of course, not enough. There is a broad and growing literature and various viewpoints on how to tackle wicked problems. Brown makes the very salient point that there is no way to see the problem until we have looked at "what should be". "What should be" is what we see as the best possible outcome or end point (2010). This is in line with Rittel's assertion that a description of formulation of any wicked problem will correspond to a proposed or stated solution (1972, p. 392).

The logical progression from this is to see the problem and the solution as flip sides of each other — you cannot have one without the other. Head urges caution here, confirming the point previously made by both Rittel and Weber (1973) and Schon and Rein (1994) that "problem definition tends to imply a preferred solution" (p. 106, 2008). My experience in research and research management is that problem and solution are often mixed up and intertwined, with conflicting "preferred solutions", causing frequent confusion and tension for researchers and funders alike.

In dealing with wicked problems, we must first acknowledge the inheritance and legacy of the Enlightenment and the Western world's ongoing love affair with technology and technological solutions. Funtowitz and Ravetz highlight that the rationality of basic scientific inquiry is no longer sufficient or universally appropriate to deal with the more complex global environmental issues, and that we are now faced with irreducible uncertainties in knowledge and ethics. They put forward a new problem solving strategy where "soft values" trump "hard facts" and where decision stakes and system uncertainties are high (1994).

We have been taught to assume that technology and science will solve all our problems and to assume that science is value-free and certain (Ravetz, 1999). Enlightenment science has focused on what Mitroff and Linstone call the first two ways of knowing – agreement and analysis – relying on shared observations then scientific analysis to define and structure problems (p. Xx, 20) and then to come up with simple, well-defined solutions.

These approaches are generally linear, as in the case of the "waterfall" approach, as critiqued by Conklin (2001). This approach progresses through gathering data, analysing this data, formulating a solution and then implementing the solution, and flowing down a series of "waterfall" steps to completion. Unfortunately, the reality of wicked problem tackling is that there are a series of "jumps" or "cycles" back and forth between problem, solution and understanding of the problem which can continue indefinitely. This is the "no stopping rule", one of Rittel and Weber's ten wicked problem characteristics (1973).

The current model of aid or international development research (and complex systems research more generally) is very much a linear one. Ramalingam gives the examples of the Millennium Development Goals (MDGs) (now replaced by the Sustainable Development Goals) as a highly ambitious set of promises which suggest that "better and more spending will lead to better goods and services" and eventually to the achievement of the targets (p. 11, 2014). This is clearly not the case. Massive sums of money and international efforts have been directed at alleviating poverty, improving equity and justice, universal education, food security for all, and so on. Donors ask for efficiency and effectiveness, for demonstrated impacts, aid accountability, for value for money and so on. And still the problems persist. No amount of money or effort will solve such problems using the kind of disciplinary "expert" tools that we use. Conklin talks about collective intelligence as an enabler of collaboration that is counteracted by the "forces of fragmentation" (p. 2, 2010). Such forces can include differences in worldview, meaning, expertise (including professional and scientific), culture, language, agenda and motivation.

Ramalingam clearly identifies development assistance problems as "wicked" and describes aid agencies as " … veritable magnets for wicked problems: they face some of the most complex and ill-defined problems in the world" (2014, p. 303), describing poverty alleviation, food security and sustainable natural resource management as subject to dynamic, interactive, non-linear and uncertain processes where cause-and-effect is almost impossible to establish.

There is a significant challenge in simply bringing all the different world-views, stakeholders, knowledge and perspectives together to create a dialogue around the wicked problem (Head, 2008; Mitroff and Linstone, 1993). Mitroff and Linstone

advocate the multiple perspective method that comprises technical, organisational or social, and the personal and individual perspective (1993). Conklin (2006) highlights the fundamentally social nature of project work, particularly the need to structure problems to take account of the diversity of worldviews, goals, assumptions and meanings that exist in a wicked problem context. In much of the literature studied here, there is a general theme of needing to achieve sustained behavioural change, a recommendation to involve a wider range of stakeholders, and often the identification of a particular stakeholder group which is not sufficiently engaged (e.g. a disengaged and passive public, the need for political leadership, etc.) (APSC, 2007; Head, 2008).

Dimensions of wicked problems (within complexity)

While opening up problem definition to a wider range of perspectives and greater diversity is crucial for tackling wicked problems, this is not sufficient by itself. Added into this are temporal, physical, social and ethical considerations.

While there are numerous descriptions of the nature of wicked problems and good examples of real life wicked problems and attempts to solve them, there are limited practical diagnostic and dialogical tools to facilitate collective identification and examination of such problems (particularly in research). Generally, ways to engage and dialogue with the broader group of stakeholders were discussed and promoted, usually with a strong focus on building consensus (Head, 2007; APSC, 2007; Conklin, 2001). The descriptions focus on what NOT to do when dealing with a wicked problem rather than what TO DO.

Ashhurst (2014) is an exception. He has developed a set of six dimensions for understanding wicked problems that he draws from a review of the wicked problems literature. He uses this framework to study the problem of low levels of numeracy achievement in low socioeconomic schools by bringing together a broad range of viewpoints from very diverse stakeholders. He represents this framework as a series of three loops of a Gordian knot, representing people-, contextual-, and system-based issues. Each of these loops includes two dimensions: diversity and intractability; complexity and ambiguity; and instability and constraints. I use these six dimensions as a pattern set to analyse the interview data.

While this framework provides a very useful tool for exploring a wicked problem there are in my opinion two key elements that are not specifically highlighted. These are uncertainty and ignorance as described by Smithson (2010)[25]. Smithson points out that within each of these terms there is considerable diversity of meanings, concepts and ways of communicating and measuring uncertainty or ignorance which are not self-integrating (p. 85, 2010). Head (2008) also uses uncertainty as one of the three factors combining to create wickidity, along with complexity, and value divergence. Uncertainty and unknowns (or ignorance) are implicit in Ashhurst's framework as I show in Table 8.

I have adapted Ashhurst's framework to use as a tool for problem identification and definition, which I test through my case study research. In particular, I test it as a potential tool for bringing together the experiences and perceptions of those engaged in the problem context. Looking through the lens of Alexander's pattern language, it is the second step of his five steps for pattern format – the context for the pattern – which explains how it completes or contributes to larger patterns.

The six dimensions of wicked problem characteristics that I have adapted from Ashhurst are diversity, intractability, complexity, ambiguity, instability and confounding factors, which I describe in the following table.

Dimension	Description
Diversity	• number and variety of stakeholders and frames • differences between stakeholders, including world view, sources of evidence and knowledge, sources of legitimate knowledge, culture • social complexity, • multiple value conflicts • sociological factors, e.g. age, status, gender, ethnicity and education
Intractability	• ability to negotiate change and compromise • flexibility of frame positions • resistance or otherwise to problem solutions • dynamic social and political factors • inflexibility of organisational or socio-political structures • unpredictability • lack of awareness of different world views and perspectives • lack of knowledge
Complexity	• consisting of many parts • many relationships/interactions among the parts • produces combined effects (synergies) • can produce surprises (element of uncertainty) • level of "messiness" • sheer number of elements and multiplicity of detail
Ambiguity	• sense of multiplicity • uncertainty • unpredictability • vagueness of fuzziness of meaning, authority, technology, goals or action • admitting of more than one course of action • lack of or uncertain data • different interpretations and conferring of meanings • contradictory tacit meanings • absence of clear authority
Instability	• dynamic nature of the problem • level of change in and around the problem itself • continual evolution • changes in thinking, situation, constraints etc. • capturing the inherent changeability of systems (physical, social and economic)
Confounding factors	• anything which restricts or limits actions or alternatives • limitations in adaptive capacity or resilience • conflicting outcomes, goals or actions • constraints – things that hold us back

Table 8: Six dimensions of wicked problems described (adapted from Ashhurst 2014)

I also see it as a useful tool for dealing with the problem highlighted by Klein (2004b) – which is the question of problem choice as well as problem solution (p. 518). She points out that in complex problems, there are many sub-problem areas across disciplinary domains, stakeholder preferences, and at horizontal and vertical scales. Navigating and deciding on the questions to tackle in transdisciplinary research can be a bewildering,

confusing and conflict-laden process. The purpose of the wicked problem dimension framework I am using in this thesis is to demonstrate the richness of both problem and stakeholder perspectives and navigate the complexity.

The point of the dimensions is not to "pin down" a particular description or definition of a particular wicked problem. Instead, I see the value of the dimensions as a tool to describe the ways in which the various research participants in a transdisciplinary team experience the wicked problem. It provides a way to bring together the varied perspectives and world-views of the researchers to provide insights and a range of options and tools to begin to tackle these problems in a research context.

Summary

There is a growing awareness of the need for literacy in the various conceptions of complex systems, some of which I outline in this chapter. In particular, I focus on the concept of "organised complexity" which I equate with self-organising systems.

A focus on complexity and self-organising systems emphasises the constant tension between order and chaos, or disordering dynamics and ordering patterns (Fenwick, 2012). This highlights the importance of complexity as practice in research, so that a system is not simply the subject of the research but applies to the process of dealing with the world, and being open to unpredictability, emergence, evolution and adaptation.

These ideas and conceptions of complexity have become increasingly aligned with the emerging literature and practice of transdisciplinary research. The first international conference on interdisciplinarity[1] in the 1970s included a call for new approaches to tackle "complex and dynamically changing situations" (Jantsch, 1972, p.102 in Klein, 2004a). And the growing literature on transdisciplinary research approaches consistently focuses on issues of complexity, and complexity as practice, as I outline in the next chapter.

[1] While the term "interdisciplinarity" was used at the conference in 1972, the term transdisciplinarity has been used more recently to describe this thinking.

CHAPTER 4
CURRENT THINKING IN TRANSDISCIPLINARITY

Albert Einstein called the intuitive or metaphoric mind a sacred gift. He added that the rational mind was a faithful servant. It is paradoxical that in the context of modern life we have begun to worship the servant and defile the divine.
(Bob Samples, 1976)

In the previous chapter, transdisciplinary research approaches are flagged as a means to not only engage with complexity in the subject of the research, but also to engage with complexity as practice. In this chapter I explore the rapidly evolving literature on transdisciplinarity including conceptions, definitions, experiences and practices of transdisciplinary research. I include literature on sustainability science here, as transdisciplinarity is seen as a key component of sustainability science which deals with complex socio-ecological systems (Brandt et al., 2013, p. 1).

Transdisciplinarity as a response to complexity

As our awareness and understanding of complexity (and its pervasiveness in the problems we tackle) increases, there is a countervailing force around compartmentalisation of scientific knowledge, as institutional structures and incentives for maintaining disciplinary silos becoming more dominant, and at the same time, the methodologies and methods associated with basic research have become more specialised and sophisticated (Hoffmann-Riem et al., 2008). There is also the suggestion that there is an "ideal of scientific knowledge" in which there is a belief that there is a universal set of concepts, theories, models and methods. This in turn leads to the assumption of knowledge transfer from researcher to beneficiary. That is, the "one-way transfer of allegedly reliable instrumental knowledge from experts to 'ignorant' users" (Hoffman-Riem et al., 2008, p. 4).

Giampietro quotes Allen et al. (2001, p. 480) who assert that a scientific paradigm is "a tacit agreement not to ask certain questions" (2004, preface). This is what makes disciplinary work possible – there are certain assumptions that are made which underlie inquiry in that particular discipline. This sharing of key knowledge, assumptions and experiences about how we know about the world is what creates a community of

practice (Wenger, 1998; Brown, 2008). The downside of this is that expertise excludes (Nowotny, 2000). For transdisciplinary approaches, there needs to be a system of inclusivity, and the assumptions described by Giampietro can no longer be taken for granted. Instead, Nowotny poses a new "narrative of expertise" which includes "transgressivity, collectivity and the socially distributed nature of the authority of different kinds of knowledge" (Nowotny, 2000, p. 20).

Popa et al. describe sustainability problems as having a "plurality of decision-makers, pervasive uncertainties, spatial and inter-temporal externalities, interplay of human and natural components and evolving understanding of policy objectives" (2014, p. 46). Klein, in talking about the co-evolution of interdisciplinarity (transdisciplinarity) and complexity, describes the shift in thinking about knowledge from a linear concept to "knowledge as a network or web, with multiple nodes of connection and a dynamic system" (2004a, p. 3). She asserts that metaphors of unity are being replaced by metaphors of plurality and relationality. Similarly, Deleuze and Guattarti (1980, in Neuhauser & Pohl, 2015) suggest that reality is made up of "multiple dimensions … with neither a beginning nor an end … but rather an infinite number of links" (Neuhauser & Pohl, 2015, p. 100).

In his discussion of lifelong learning and integrative development, Kolb talks about the way in which we are constantly challenged by the simultaneous forces in our society of the push of intense specialisation and the pull of increasing diversity (1984, p. 209). He sees this as simultaneously threatening to divide us, while at the same time opening doors for integration and integrity. Thus he poses the learning challenge as one of integrative development. He also points out that professional specialisation may inhibit development of an integrative perspective, and that the goal of personal integration and development is attained through a dialectic process of adaptation to the world.

Furthermore, Hirsch Hadorn et al., (2008) argue that the science of the Enlightenment has been detached from practical life and becomes an ideal of universal, explanatory truth, demonstrated and taught by standard methods. They use Edmund Husserl's term "Lebenswelt" or "life-world" to describe the practical, lived experience of the world. In this way, they create a sense of two worlds – one academic or disciplinary and the other the "life-world". Nowotny et al. (2001) echo this, in their descriptions of the divide

between science and society and the urgent need to bring them together.

These authors highlight the "inability of our specialised disciplines to offer comprehensive solutions to the conditions that threaten the sustainability of global, social and human systems" identified in sustainability science as the three key levels of system (Komiyama & Takeuchi, 2006). In the next section, I explore the current thinking on transdisciplinarity among key authors and practitioners in the field.

Current state of transdisciplinarity

There is a clear and important distinction between multi-, inter- and transdisciplinarity. Multi-disciplinarity works on parallel disciplines at the same time, interdisciplinarity involves researchers working together but still from a discipline-based approach though with the transfer of methods from one discipline to the other Rosenfeld (1992). Transdisciplinarity is at the same time between, across and beyond disciplines, and relies on a shared conceptual framework that goes beyond disciplines and the walls of academia to incorporate a broader range of concepts, theories and approaches (Nicolescu, 2014; Max-Neef, 2005; Rosenfeld, 1992). Jurgen Mittelstrass defines transdisciplinarity as "a form of research that transcends disciplinary boundaries to address and solve problems related to the life-world" (Mittelstrass, 1992 in Hirsch Hadorn et al., 2008).

Transdisciplinarity can never lead to a "super-discipline" or a single unified approach simply because (unlike disciplines and interdisciplines) by definition there can be no boundaries (Nicolescu, 2014). Transdisciplinarity and its need to breach boundaries have arisen from societies' inability to deal with problems such as climate change, health, land degradation, nutrition, poverty and planning (Lawrence, 2004). I describe these problems as wicked problems in the previous chapter.

Klein (2008), in her review of transdisciplinary and interdisciplinary research and evaluation, points out that the methodologies and conceptual frameworks for transdisciplinarity are various. She identifies three main schools of thought or "clusters" in transdisciplinarity, including the international network of interdisciplinary research, transdisciplinary team science (largely US based) and transdisciplinary trans-sector, problem-oriented research with stakeholders (largely Europe-based).

Since its early definition during the First International Conference on Interdisciplinarity in Paris in 1970 (Klein, 2004a), the literature on transdisciplinarity has expanded exponentially, particularly in the past decade. This literature represents a plethora of ideas, investigations and practices dispersed across a wide range of fields of endeavour within and beyond research (Klein, 2014). Gibbons et al. (1994) make a distinction between what they call Mode 1 and Mode 2 science saying that Mode 2 goes beyond disciplines (Mode 1) to include broader societal knowledge. Hoffmann-Riem et al. describe this as stepping outside of academia "opening the doors of laboratories and libraries" and "engaging in mutual learning with people in the life-world" (2008).

Gibbons et al. (1994) describe this as transdisciplinary research with the following four features. Firstly, the problem-solving framework is developed in the context of, and in response to, the application. This characteristic is very similar to the iterative processes described by Layder (2005). The second characteristic is that of unique theoretical structures, research methods and practice for transdisciplinary knowledge that will be unlikely to sit within disciplinary boundaries. Thirdly, communication of results and exchange of knowledge will generally occur as part of knowledge production in the problem context. The final point is that transdisciplinarity requires a dynamic approach to problem solving and knowledge generation. Hence a particular solution can become the jumping off point for a new inquiry or a series of new inquiries. This aligns with Ansell's (2011) concept of evolutionary learning (which I discuss in the next chapter).

Pohl and others provide a succinct summary of the challenges.

> Transdisciplinary Research takes into consideration a large array of potential disciplinary paradigms and life-world perspectives, and it explicitly narrows down its focus to a few of them in the phase of identifying and structuring problems. TR takes into account that knowledge about problem fields is uncertain and social groups stakes are high. Moreover, TR takes into account the fact that the definition and analysis of problems constitutes disputed ground. (Pohl et al., 2007, p. 37)

Lang et al. (2011) summarise three key arguments in the literature for transdisciplinary research in sustainability science approaches. Firstly, that multiple knowledge communities are needed to provide input to cover off on the diverse nature of complex

problems; secondly, that finding solutions must go beyond rational and empirical approaches to include values, goals, norms and visions for possible solutions, and thirdly, broad collaboration with a range of stakeholders can enhance ownership, legitimacy and social robustness of solutions. Of the plethora of transdisciplinary endeavours and contributions in the literature, many of them lack a clear conceptual framework (Lawrence, 2015). Lawrence suggests that such an omission stands in the way of cumulative and collective advances in understanding of particular problem areas as well as advances in transdisciplinary research approaches.

Klein (2014) highlights the plurality of conceptions and approaches to transdisciplinarity, and its tendency to be conflated or to overlap with interdisciplinary approaches and framings. She describes three major discourses of transdisciplinarity: transcendence, problem solving and transgression, and suggests that a "meta-TD" is unlikely to unify separate approaches. While all three discourses are represented in transdisciplinarity, it is likely that transdisciplinarity will be more closely aligned with epistemological transcendence (2014). This transcendence is at odds (though not completely) with the ongoing quest through the history of Western thought for an ideal of unity in science.

Nicolescu (2014), on the other hand, argues for a consistent methodology for transdisciplinarity. He specifies a threefold theoretical, phenomenological and experimental transdisciplinarity, where theory implies a well-defined methodology but multiple methods and where phenomenology concerns building models to connect methodological principles with experimental data. Max-Neef goes further and suggests two alternatives for transdisciplinary research tackling wicked problems – suggesting either a "weak" or "strong" transdisciplinarity (2005). The first, weak transdisciplinarity, relies on following traditional methods and logic. The second, strong transdisciplinarity, "represents an epistemological challenge that introduces a kind of quantum logic … and breaks with the assumption of a single reality" (Max-Neef, 2005, p. 5).

Max-Neef (2005) defines "strong" transdisciplinarity as being based on the three fundamental pillars identified by Nicolescu (1998). These are levels of reality, the principle of the included middle, and complexity, thus challenging traditions of linear and binary logic (Max-Neef, 2005). The first pillar is essentially an acceptance of the

fact that there is no one single reality which is fully describable and understandable, and that there may be various states and perceptions of reality between individuals as well as for individuals. The second pillar, the logic of the included middle, cuts through the concept of a binary world and introduces the concepts of paradox, creative tension and anti-dualism (which I discuss in more detail in Chapter 5). Here he introduces the concept of recursive thinking as proposed by Edgar Morin, to enable thinking "capable of establishing feedback loops in terms of concepts such as whole/part, order/disorder, observer/observed, system/ecosystem, in such a way that they remain simultaneously complementary and antagonistic" (Morin, 1992 in Max-Neef, 2005). The third pillar – complexity – acknowledges the non-linear processes, chaos and the idea of self-organising systems, which I explore in Chapter 3.

Max-Neef concludes by identifying strong transdisciplinarity as a "different manner of seeing the world, more systemic and more holistic" (2005, p. 15). He also concludes that applying transdisciplinarity methodologically is still problematic.

Wiek and Lang (2016) describe two distinct forms or streams for sustainability science or transdisciplinary research. These are "descriptive-analytical" and "transformational", and they emphasise the difference and its importance. While the former is focused on understanding the problem, the latter goes beyond problem understanding and analysis to problem solving and requires clear but plural methodological guidelines, sufficient understanding of the problem, and close collaboration between researchers and practitioners and other stakeholders.

In this thesis, I draw on Max-Neef's concept of "strong" transdisciplinarity, and Nicolescu's idea of a consistent methodology for transdisciplinarity, but (perhaps paradoxically) tempered by Klein's and others' wariness of unity and a unified approach. Instead I explore and develop a relational methodology for transdisciplinarity, which emphasises the heterogeneity and relationality of knowledge, and the importance of relationships between things and actors beyond the notion of the things themselves (Klein, 2014). This leaves room for a methodological approach based on principles, which can potentially embrace and capitalise on diverse epistemological framings and a diversity of worldviews and methods.

Evolving approaches in research for rural development

The history of research for rural development serves as a useful example of the evolution of approaches towards a more widely inclusive research approach, and the bringing together of the physical and social sciences as well as a more inclusive approach to working with other stakeholders, including beneficiaries of the research.

At the time of writing, there appears to be limited material in the literature linking transdisciplinarity and rural research for development. Francis et al. (2008) propose "a holistic, ecological and transdisciplinary strategy for research in the agriculture and food sector", and suggest agroecology as an integrative alternative to disciplinary approaches. They limit their definition of transdisciplinarity to "mean the integration of methods and information from several disciplines, as compared to 'multidisciplinary' that means a collection of disciplines that are not necessarily integrated" (Caporali et al., 2007 in Francis et al., 2008). However, they do acknowledge the importance of the close connection between research, learning and action, and promote an experiential learning approach.

In agricultural research for development, early traditional approaches were linear, or top-down, with research carried out by the scientists, and results packaged by extension or advisory services for the farmer (Carr & Wilkinson, 2005). This approach tended to encourage a supply-driven and disciplinary focus (Probst et al., 2003) and is the approach that largely underpinned the Green Revolution. The Green Revolution is credited with solving the 1960s food crisis through its massive contribution to reducing hunger, improving nutrition and raising farm incomes. However, it is also credited with failing to address the needs of small farmers and those in marginal, risk-prone and diverse environments to the point of being called "peasant unfriendly". At the same time, it has created a range of environmental and other social issues that remain unresolved (Das, 2002; IFPRI, 2002; Harwood, 2009; Ellis & Biggs, 2001).

From the 1970s onwards, there has been a growing awareness of the importance of social and cultural contexts and there has been much written on participatory approaches, rural livelihoods frameworks, action research and other approaches, as well as a growing understanding of our impact on our environment and the need to consider environmental and production issues together (Probst et al., 2003; Roling, 2002;

Johnson et al., 2003; Ellis & Biggs, 2001; Scoones, 1998). Such approaches are intended to be more inclusive of, and take account of, input by farmers and other stakeholders in research, and in particular to adapt technology to suit farmers' specific needs (Johnson et al., 2003). Participatory research approaches also vary significantly, for example the five typologies developed by the CGIAR Program on Participatory Research and Gender Analysis (PGRA) (Johnson et al., 2003). Many of these inclusive approaches tend to blur the scientist-extension-recipient boundaries, but still preserve a largely linear, top-down process.

More recently, research into knowledge management and social learning has focused on the importance of inclusion of different kinds of knowledge, including that of farmers and other non-scientific groups. Thompson and Scoones (2009) describe two contrasting streams of agricultural science. The first is founded on experimental science and involves taking a narrow focus on specific variables to reduce uncertainty. This stream produces "individual building blocks of an edifice, but not the architectural design". The second approach is an holistic one, requiring synthesis and a systems focus. It relies on integration and transdisciplinarity to bring together multiple sources of evidence and knowledge.

A number of authors have more recently defined and discussed agricultural research and development as a social process, and agriculture and resource management as a systems process that is complex, unpredictable and often intractable (Douthwaite et al, 2003; Probst et al., 2003; Klerkx et al., 2010; Thompson & Scoones, 2009; Edquist and Edqvist, 2008). Probst et al. (2003) also point out that agricultural science is regarded as interdisciplinary or at least halfway there, in the sense that there tends to be a greater focus on the agricultural problem resolution than on the field or discipline. So there is a growing acknowledgement of the need for a two-way flow of information between scientists and farmers and other groups (Richards, 2007; Pahl-Wostl, 2006; Thompson and Scoones, 2009). However, in complex systems approaches, the problem remains, that bringing together radically different epistemologies, ways of knowing or world-views, is challenging and the different views difficult to reconcile. In the next section I highlight some of the challenges associated with transdisciplinarity.

Challenges in transdisciplinarity

The challenges and problems of transdisciplinarity are multiple and derive largely from the bringing together of vastly different views and approaches. These challenges include the science world's preference for "hard" data (i.e. the reliance on numbers), the inevitable diversity and potential conflict between goals, values and expectations. And underlying all of this is the (often unacknowledged) issue of power, and the imbalances and asymmetries in the power of different worldviews or ways of knowing.

Kessel and Rosenfield, looking at historical and contemporary perspectives on transdisciplinarity, say that "research that consistently and creatively crosses disciplinary, departmental and faculty lines remains relatively difficult to initiate, fund, publish and sustain" (2008, p. S225). Funding is generally allocated according to discipline-based organisational structures and the disciplinary expertise of those making the decisions. In addition, some disciplines are more powerful than others. Even when different disciplines are integrated, there is a "tendency to sideline concepts and approaches that are incompatible with 'hard' knowledge" (Klein, 2004b, p. 520) and to wind up with purely symbolic participation of these concepts, ignoring the diversity of goals, values, expectations and power imbalances (Wiesmann et al., 2008).

There are inherent issues of communication associated with transdisciplinary research. There are so many differences to bridge in terms of research methods, epistemologies, work styles, assumptions as well as language (Klein, 2004b, p. 520). This is further exacerbated with the inclusion of beyond-disciplinary "Lebenswelt" stakeholders, not to mention multi-lingual and international collaborations where fundamental cultural differences need to be bridged. In addition, there is the challenge of geographical differences, and the need to distinguish between the "universalising drive of scientific inquiry and the instinct to make global kinds of knowledge" (Hulme, 2010, p. 559). Global kinds of knowledge erase cultural differentiation and heterogeneity, which fails to do justice to the heterogeneity of human livelihoods and situations, and are likely to be much less helpful in policy setting and problem solving (Hulme, 2010).

Transdisciplinarity is paradoxical in the sense that it is at the same time "unity in diversity and diversity in unity" (Nicolescu, 2014, p. 188). On one hand, there is the risk of reduction, and on the other hand the possibility of chaos and discord. This has

implications for transdisciplinary research, as complex, intractable problems bring together a broader collection of specialisations and points of view, in which conflicting forces of the push to specialisation and the pull of increasing diversity are increasingly thrown into relief. Wickson et al. summarise the idea of seeking coherence, correspondences and "ridges" across differences, "generating knowledge by finding, identifying and communicating patterns across diverse disciplines and discourses" (2006, p. 1053).

Hirsch Hadorn et al. talk about the "bigger picture of ongoing and intertwined transformations in academia and the life-world" as important context for an understanding of transdisciplinary research, and to understand why "transdisciplinarity is a fuzzy and contested field, shaped by various lines of thinking, heterogeneous conceptions of science and approaches to research, with a variety of terminologies and definitions" (2008, p. 27) whereas Parkes et al. (2005) title their paper on transdisciplinary approaches to dealing with infectious diseases "All hands on deck", to signify the need for collaboration and concerted effort in addressing the increasing burden of infectious diseases, and acknowledging the complex social and ecological systems contexts.

The idea of complexity, and a contextual and ever-changing perspective on reality, challenges the Western idea of a coherent world, and the associated linearity and universal laws (Deleuze and Gauttarti, 1980 in Neuhauser and Pohl, 2015). Instead this suggests that the world is much more fragmented with reality consisting of "multiple dimensions" or "directions in motion". Deleuze and Gauttarti describe no beginning or end, but a network with an infinite number of links. To achieve understanding requires an examination of these multiple dimensions, which requires multiple disciplines and perspectives or a "collective" approach (Brown and Harris, 2014).

With all this complexity, multiple realities and ever-changing perspectives on reality, the issue of clear problem definition is a major challenge. Lack of problem awareness, and insufficient understanding of problem and context are illustrated and addressed by Lang et al. in a project for innovative community-based energy strategies. Establishing a clear problem definition requires significant time and effort, to establish a common understanding of the problem being addressed, and they emphasise the importance of

achieving this before beginning to design the project (2011).

Other challenges highlighted by Lang et al. include unbalanced problem ownership, insufficient legitimacy of the team or actors involved, conflicting methodological standards, lack of integration, vague and ambiguous results, fear of failure, lack of legitimacy of transdisciplinary outcomes, discontinuous participation and tracking impacts.

One of the key challenges of transdisciplinarity is the tendency to regard it as a "*eierlegende Wollmischsau*" or egg-laying, wool-bearing dairy pig, inferring unrealistic expectations of transdisciplinary researchers as being "all things to all people" (Pohl et al., 2007, p. 37). In his analysis of 27 interviews with social and environmental researchers, Pohl (2005) concludes that the researchers perceived the requirement to collaborate outside their own discipline as yet another demand, and that they felt they needed several years to become "used to" each other's culture. And that, under pressure to produce and report results, it was more expedient to divide labour between the disciplines. At the very least, this highlights the challenges for practitioners to learn how to do transdisciplinarity (Lang et al., 2011). And this raises the question of what is it to be a transdisciplinary practitioner, and what constitutes transdisciplinary practice?

What is transdisciplinary practice?

Transdisciplinary research and inquiry is largely seen as a collective endeavour, involving multiple world-views, perspectives, kinds of knowledge, values and assumptions. But all research teams are made up of individuals, and my focus in this thesis is to study transdisciplinary research practice, which must at some stage focus on the individual or practitioner. While it may seem counterintuitive to talk about a transdisciplinary individual, this thesis is about the study of individual lived experience and the practice of transdisciplinarity. Lang et al. highlight the absence of a synthesis of experience-based guidelines and practical experiences for the practice of transdisciplinarity (2011). Augsburg investigates the idea and process of "becoming a transdisciplinary individual" (Augsburg, 2014, p. 233).

Augsburg quotes de Freitas et al. 1994 (in their Charter of Trandisciplinarity) as identifying characteristics for "the cultivation of a transdisciplinary attitude and vision

among individuals" (Augsburg, 2014, p. 236). These characteristics include tolerance and acceptance of the unknown and ideas opposed to one's own, rigour in argument, openness to myth and religions, recognition of different levels of reality and respect for the collective. In addition, individual creativity, inquisitiveness, adaptability and flexibility are key attributes in transdisciplinary practice (Nicolescu, 1999 in Augsburg, 2014).

Transdisciplinary skills and traits include mutuality, trust, ability to build networks in unfamiliar territory, ability to engage in meaningful dialogue while suspending one's own viewpoint, societal conscience and awareness, ability to relate to complexity and a modicum of humility (Augsburg, 2014), a less than modest list. She adds to this the characteristics of the risk taker, self-confidence and strong self-identity, willingness to share autonomy, responsibility and knowledge and the ability to see a "community of perspectives (rather than a collection of people)" (2014, p. 240). Further study of the various personal experiences of transdisciplinarity are needed to enhance this understanding (Augsburg, 2014).

In investigating principles and processes to enhance transdisciplinary practice, Lang et al. propose a three-phase research process. Phase A is the collaborative framing of the problem and team formation; Phase B is the co-production of knowledge through collaborative research; and Phase C is the re-integration and application of the co-produced knowledge in scientific and societal practice (2011, p. 27). Within each of the phases, they describe design principles and guiding questions to focus these. These nclude a number of useful principles including collaborative definition of context, problem and methodological framework; integrative methods and approaches for co-production of knowledge; integration of project results for problem solving and existing scientific knowledge; continuous and iterative formative evaluation; and constructive approaches to conflict. The non-linearity of this process is emphasised, and the importance of building on not just societal solutions but also adding to knowledge in transdisciplinary practice. This requires reflexivity and recursiveness.

Popa et al. place reflexivity at the centre of knowledge production in transdisciplinary practice, and highlight two approaches to this. The first is a deliberative approach which takes a more socio-normative view and focuses on a more "democratic" science to

encompass a wider range of views. The second approach is based on philosophical pragmatism, where reflexivity is part of a more open-ended inquiry process, where participants jointly question and reframe world-views, values and understanding (2015). In this way, they position research as being a "socially-mediated process of problem-solving based on experimentation, learning and context specificity" (Popa et al., 2015, p. 48). In the previous chapter (Chapter 3) I explore the importance of context specificity as a critical focus for wicked problem framing and dimensions. In the following chapter (Chapter 5), I explore the importance of framing transdisciplinary research practice as a learning (including experiential, collective and evolutionary) and reflexive process.

They argue for reflexive processes in the practice of transdisciplinary research at the epistemological, normative and participatory level. The first is to ensure improved problem framing and methodology, the second to better manage value differences and conflicts, and the third at the practical level, to mobilise support and buy-in from key stakeholders.

Wickson et al. (2006) also focus on reflective practice, in the context of the three challenges or quandaries of transdisciplinary research. These three challenges are the potential for many different dimensions and scales of integration; the need for researcher reflection on their own frames of reference, beliefs and assumptions in relation to the research and the knowledge they bring to bear on the problem; and the inevitable problem of paradoxes.

Brown and Harris talk about the importance of reframing our ideas of paradox and other areas of tension, and looking at relationships between opposites including parts and wholes, stability and chaos, individuals and society, and rationality and creativity. In collective thinking, these opposites can be re-cast as a series of relationships. In their words (drawing on Bateson), "reflection on the patterns that connect is more important than concentrating on the differences that divide" (2014, p. 83). This provides an alternative to the "binary logic that dominates modern Western thought and the problem of paradox that it creates" (Wickson et al., 2006, p. 1054).

In a slightly different vein, Neils Bohr (the famous physicist) suggested the concept of "complementarity" which is the idea that two different worldviews or interpretations of

reality can be valid and useful at the same time. He gives the example of both wave and particle theory being simultaneously valid ways to describe light (Brown, 2008). I use all of the above concepts in the development of the transdisciplinary methodology in this thesis.

Measuring and evaluating transdisciplinarity – what is quality?

Given all the challenges associated with transdisciplinary practice, understanding what is quality in transdisciplinary research, and how it should be evaluated is an important question (Wiesmann et al., 2008). Evaluation of transdisciplinary research remains one of the least understood aspects in the range of literature on inter- and transdisciplinary research practice (Klein, 2008). While research within disciplinary boundaries is generally subject to disciplinary-based peer review, new approaches and thinking are required for evaluating transdisciplinary inquiry. Given that research is generally evaluated on the basis of the methodological and quality standards of disciplines, this leaves an opening for a set of criteria to apply to transdisciplinarity (Belcher et al., 2015). Wickson and Russell highlight the difficulties of transdisciplinary evaluation, given that evaluations are generally performed by disciplinary peers, which is not possible in transdisciplinary projects (2006). The highly contextualised nature of transdisciplinary research makes this doubly difficult.

In the following section, I outline a number of sets of evaluation principles and criteria from the literature, and highlight the diversity of perceptions regarding what constitutes good transdisciplinary research and what various authors regard as important.

Klein also emphasises the breadth of levels, criteria, integration scope and heterogeneity of inter- and transdisciplinary research (2008), which defies the quest for a consistent methodology and practice for both the research and its evaluation, but instead, proposes seven generic principles of evaluation. These are:

1. Variability of goals
2. Variability of criteria and indicators
3. Leveraging of integration
4. Interactions of social and cognitive factors in collaboration
5. Management, leadership and coaching

6. Iteration in a comprehensive and transparent system
7. Effectiveness and impact
   (Klein, 2008, p. S116)

Klein highlights the gap between conventional measurement and the requirements of transdisciplinary research evaluation.

Bergmann et al. also provide a set of distinguishing characteristics for transdisciplinary projects including problem orientation and problem translation (translating problems of everyday life into research questions), actor orientation (with interaction with societal practitioners essential), and transdisciplinary integration of knowledge and context-relatedness (taking into account local framework conditions and possibilities for action) (2005, p. 16). Though they stress that this is work in progress, they emphasise the importance of the formative function of evaluation for both the research team and the evaluators, as this focuses on the goal of learning.

Wickson and Russell propose six criteria for evaluating transdisciplinary research using a set of synthesised characteristics developed by Glassick and others at the Carnegie Foundation to evaluate the work of academics. They are:

1. Clear goals – the scholar identifies important questions in the field, clearly articulates the purpose of the work and defines realistic objectives.

2. Adequate preparation – the scholar demonstrates an understanding of existing knowledge in the field and brings the necessary skills and resources to the project.

3. Appropriate method – the scholar selects and effectively applies methods appropriate to the goals and modifies these methods in response to changing circumstances.

4. Significant results – the scholar achieves set goals, makes an important contribution to the field and highlights new areas for exploration.

5. Effective presentation – the scholar employs appropriate means (style, medium, forums etc) to clearly communicate the work to its intended audience.

6. Reflective critique – the scholar uses a breadth of evidence to critically evaluate their work and through this process improves the quality of future endeavours.

(Wickson & Russell, 2006. p. 1056)

While these six criteria are practical and sensible, they do not provide any particular guidance as to how transdisciplinarity is distinguished from disciplinary endeavour.

Russell's (2010) systematic framework for assessing the reliability of knowledge provides a more useful view. She brings together a set of principles for an open and critical transdisciplinary inquiry where there is knowledge contestation by virtue of the differences in disciplinary and non-disciplinary framings that are brought together. Briefly they are:

1. The partiality, plurality and provisionality of knowing.
2. Foundations for reliable knowledge requiring not only evidence and reason, but a social process of critical deliberation (and avoiding a relativist position where any old knowledge will do).
3. That validity and critical rationality can only be achieved through inter-subjective critical reflection.
4. An ontological commitment to openness and an expanded view of what is "real".
5. Including facts as well as values in the inquiry process and validation (which can be challenging in the realm of science).
6. And a commitment to, and openness around, Aristotle's three knowledge commitments: the ontological, epistemological and ethical.
7. A commitment to ecological sustainability and social justice as part of furthering knowledge and human interests (Russell, 2010, p. 56-8).

She describes the knowledge of science as one of a raft of different knowledge communities which find commonalities through what Popper (1959 in Russell, 2010) describes as "commonsense".

Russell (2010) talks about constraints on our ability to know the world, and the value-laden nature of observation. She quotes Hansen (1958) on the Duhemian problem that a lay observer in a physics laboratory cannot see what a physicist sees, as "the act of seeing is value-laden" (Russell, 2010, p. 36). Brown and Harris (2014) go a step further and describe the seven domains of human understanding, which they assert are common to all humans. The importance and implications of this is discussed further in the

following chapter.

Finally, Pohl and Hirsch Hadorn suggest four principles for transdisciplinarity. These are:

1. Reduce complexity by specifying the need for knowledge and identifying those involved.
2. Achieve effectiveness through contextualisation.
3. Achieve integration through open encounters.
4. Develop reflexivity through recursiveness (Pohl & Hirsch Hadorn, 2007).

Evaluation generally has a dual purpose; as an accountability mechanism, and secondly for learning and iterative design. Belcher et al. emphasise the importance of the evaluation process itself as essential to the goals of mutual learning (2015). Learning becomes even more important in transdisciplinary research as opposed to disciplinary endeavours, given that there is a lack of institutions and formalised peer communities (with a few exceptions) to accumulate knowledge and create continuity (Hoffman-Riem et al., 2008). Concepts of evolutionary learning, and triple-loop learning are discussed in Chapter 5.

A key test of transdisciplinary research is its application, or how effectively knowledge is integrated, rather than the more traditional view of research translation to "research knowledge that … eventually serves the public" (Neuhauser & Pohl, 2015, p. 102) Instead, science and society are interlinked and the various stakeholders in both the "Lebenswelt" and the research world are actively (and equitably) engaged in the knowledge generation activities.

Dovers (2005) says "The need for transparency and critical evaluation entails that integration of disciplinary perspectives cannot be a matter of simple summation of the results, but must be core to problem definition and research design."

He also makes the point that different contributing disciplines may deal with aspects of scale through embedded theory and methods, and that this may have varying levels of visibility. In other words, assumptions within disciplines and the underlying world-views, epistemologies or theories (however they may be termed) are taken for granted or partly forgotten by those within the discipline, and may be invisible and unknown to

those outside the discipline. He argues that these differences need to be confronted if integration is to be effective. This can be challenging if the differences are not acknowledged or are tacit or invisible.

Summary: transdisciplinary practice as resolution

Through the review of current thinking in transdisciplinary research and its practice, I have drawn on key themes that I see as central to the development of transdisciplinary practice and methodology. Firstly, I take Max-Neef's concept of strong transdisciplinarity and the idea of exploring an overarching or relational methodology to unite the practice of transdisciplinarity (but not to make it uniform). To be relational and overarching, I adapt Nicolescu's argument for a threefold theoretical, phenomenological and experimental methodology, where the theory provides for a well-defined, principles-based methodology, and where I investigate models and tools to connect the principles with the elements of practical inquiry, inquiry and data collection, leaving the doorway open for multiple worldviews and research methods. In this case, I adapt Alexander's pattern language as the link.

Co-production of knowledge emerges as a key theme in the literature, as does the importance of research as a recursive learning process. The following chapter (Chapter 5) investigates key themes in transdisciplinary thinking that emerge from this chapter including the logic of the included middle (including paradox and creative tension), the need for recursiveness, collective and evolutionary learning, and reflection and reflexivity.

Finally, I also focus on transdisciplinary practice, looking from the perspective of the individual practitioner, through team practice, to a more global view. In the findings chapters (Chapters 7 to 11), my primary focus is on exploring the lived experience of transdisciplinary practitioners as a pathway to a better understanding of transdisciplinary practice and a methodology to support this.

CHAPTER 5
DEVELOPING TRANSDISCIPLINARY PRACTICE: LEARNING, PARADOX, KNOWLEDGE SYNTHESIS AND REFLECTION

> Human beings, who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so.
> (Douglas Adams and Mark Carwardine, 1990)

The review of the literature on transdisciplinarity in the previous chapter (Chapter 4) highlights an approach to exploring complexity that involves bringing together different worldviews and kinds of knowledge including (but not restricted to) various disciplinary kinds of knowledge. The concept of combining and constructing different kinds of knowledge highlights the need to explore the literature around knowledge construction and sharing, both social and individual. It also indicates the need to explore social learning processes that set the scene for transformational change and new thinking, rather than incremental learning within set assumptions and beliefs. In particular, I look at the challenges and opportunities of bringing together conflicting and competing worldviews, and the centrality of creative tension and various forms of knowledge conflict.

Social learning

There is a wealth of literature concerned with social learning and its importance in bringing together a wide range of stakeholders with potentially different perspectives, expertise and world-views in socio-biophysical systems research and innovation, particularly in water management (Pahl-Wostl, 2006; Hoverman et al., 2011; European Commission, 2003; Rodela, 2011). Pahl-Wostl (2006) talks about social learning in the context of river basin management, in which collective action and conflict resolution are achieved through more collaborative action and a change in the role of information from expert advice to an emphasis on supporting communication, and an iterative and ongoing process. There is debate about how this happens and what it means. Nor is it clear what positive actions result from this, or indeed what actions can be expected (Reed et al., 2010).

Wenger talks about learning as being an essential part of our human nature, and a fundamentally social process, as opposed to the kind of formalised, institutionalised learning we practice in schools and universities (1998). He identifies four components of a social theory of learning: meaning (learning as experience); practice (learning as doing); community (learning as belonging); and identity (learning as becoming). His social theory of learning uses concepts of identity and community of practice as key underpinnings. Similarly, Fleck (in Cohen & Schnelle, 1986) describes "*Denkstil*" and "*Denkkollektiv*" or thought styles and thought collectives in science, highlighting the collective nature of knowledge and of science.

Similarly, mutual learning is a related concept that focuses on increasing mutual understandings (group and individual) of facts, values and interests, and is carried out through informal exchanges of knowledge and experiences. Mutual learning is often associated with participative processes and the collaboration between those from the scientific and non-scientific worlds with the aim of producing legitimate and socially accountable knowledge (Polk & Knutsson, 2008; Scholz et al., 2000).

Both Wenger and Fleck say that we all belong to multiple communities of practice in our everyday lives, and that these are often invisible to the members. Further, that communities of practice or thought collectives are heterogeneous, as members will inevitably belong to a number of these communities of practice. Fleck specifically uses the term thought collective to describe the "social unit of the community of scientists in a field" (Cohen & Schnelle, 1986, p. Xix) His specific definition is as follows:

> A community of persons mutually exchanging ideas or maintaining intellectual interaction(:) we will find by implication that it also provides the special "carrier" for the historical development of any field of thought as well as for the given stock of knowledge and level of culture

(Fleck 1979, p. 39 in Cohen and Schnelle, 1986, p. Xx).

For researchers undertaking transdisciplinary work, this can be problematic – that is, it may be difficult to establish a sense of community and belonging, and identity is not clear (one doesn't belong to a particular discipline). This would explain the desire among many researchers who breach disciplinary boundaries to create a new bounded

knowledge or community of practice or disciplinary home in which to belong and identify (Bammer, 2013).

While such specialist knowledge cultures are important and even essential, their principle danger is the temptation to see one's own "*Denkkollektiv*" or knowledge culture as the only way or the right way to think. Not only this, but there is the ever-present danger of being unaware of fundamental epistemological differences. A personal example is my own undergraduate education as a crop agronomist and plant breeder. Lacking a grounding in philosophy of science (my degree did not offer this) or in methodologies more generally, it was a great revelation to me to learn that there were so many ways of knowing and understanding the world beyond post-positivism. The effect on me was a metaphorical "jailbreak" and the ability to breathe new air and think new thoughts.

Social learning, however, needs to happen beyond the boundaries of communities of practice, disciplinary groups, knowledge cultures or other groups that habitually learn from each other. The implication of this is that knowledge can be constructed not only within groups who are like-minded or share similar world-views, knowledge etc., but also across broad and even fundamentally different knowledge and beliefs.

Reed et al. (2010) highlight the confusion around the difference between individual learning (much of which occurs as a result of social interaction) and social learning and participatory processes. In their response to a range of the social learning literature, they suggest that for social learning to occur, it must lead to a change in understanding, values and beliefs at a sufficiently broad scale through social interaction (Reed et al., 2010) They suggest a three point definition of social learning – demonstrated learning amongst the individuals involved, that the learning is happening across a broader social spectrum, and that the process takes place through social networks.

According to Reed et al. (2010) social learning can be said to have occurred if it is happening beyond (but also within) organisations, social units and communities of practice and knowledge cultures in which learning generally occurs. This could be said to be the case in a transdisciplinary research team, where the participants are derived

from a broad range of disciplinary, social, cultural and organisational groupings. For social learning to occur in this case would require changes in understanding, beliefs, knowledge and assumptions across a broad spectrum of people and groups.

Social learning is an everyday occurrence, and is the "pathway through which we learn to live in a shared world" through mutual learning among all a society (Brown & Lambert, 2012, p. 3). Brown and Lambert also point out that social learning is a mixed blessing, describing it on one hand as "the glue that holds society together" and on the other hand as a potential "brake on change" if it is concerned with maintaining traditional ways of knowing rather than change or transformation (2012, p. 4). The interaction between the two possibilities creates a tension and conflict that can be creative or destructive. Social learning presents a challenge as, according to this definition, it can only succeed when divisions in ways of thinking are bridged.

Experiential and evolutionary learning

My theoretical framework draws on the Pragmatist literature, including experiential, experimental and evolutionary learning/inquiry and the concept of paradoxes, dualisms or the double bind, and the notion of collective mind. With regard to learning, the key concepts here include the ways in which individuals and groups learn, both individually and collectively. In particularly, I focus on learning and problem solving for real-world wicked problems in complex systems.

Kolb's experiential learning cycle describes the ways in which individuals learn in a social context. Kolb posits an experiential learning theory that combines cognitive and behavioural learning theories (including the work of Dewey, Pierce, Lewin and Piaget) as a "holistic integrative perspective on learning that combines experience, perception, cognition and behaviour" (1984, p. 21). This theory is widely used and accepted and is the basis for much of the theory and methods associated with adult learning and capacity building approaches.

However, Ansell (2011) goes a step further, saying that experiential learning, which occurs in response to real problems, can occur without reflexivity about one's own habitual knowledge. He suggests that learning can progress from experiential to experimental, once reflexivity occurs. Ansell is quite clear about when experimental

learning can be said to occur. He emphasises the provisional, probative, creative and socially constructed nature of experimental learning, and deliberately excludes the "restrictive sense of a randomised controlled experiment" (Ansell, 2011, p. 12). Therefore, he claims such learnings are partial, provisional and fallible and require recognition of uncertainty and ambiguity. This aligns with the wicked problem framings, in that any solutions (or learnings) are partial, provisional and there is a no stopping rule.

From there, Ansell says that when "individuals and groups learn to use experimentation and inquiry to 'reconstruct' their experiential knowledge and skills, this approach can lead to continuous learning and growth – to evolutionary learning" (2011, p. 10). He proposes three "generative conditions for evolutionary learning" (Ansell, 2011, p. 11). The first condition is a problem-driven approach that challenges existing assumptions, values and knowledge. The second condition is reflexivity, in which there is critical and self-conscious reflection on habitual knowledge. And the third is deliberation which occurs in response to the tension between two different and opposing perspectives and has communication (or Charles Pierce's "communities of inquiry") as a central focus for problem solving and new knowledge creation. According to Pragmatist thinking, action is central and a prerequisite to discovering meaning (Ansell, 2011, p. 11).

Another potentially useful framing is that of transformative and generative learning. Taylor (1998) links transformative learning back to the work of Mezirow (rational transformation), Boyd (individuation) and Freire (social transformation). Similar to the Pragmatist concept of evolutionary learning, the focus is on challenging existing beliefs, paradigms and values and is seen as a key level for change (Kläy et al., 2015; Mitchell et al., 2015; Abson et al., 2016).

Recursiveness lies at the heart of the Pragmatist idea of evolutionary learning and, I suggest, in transdisciplinary research, should be closely and productively coupled with developmental evaluation. Developmental evaluation, as defined by Patton, is a combination of both formative and summative evaluation, that is, focusing on improving and adapting the inquiry as well as making judgments about the project at the same time (2011, p. 1–7). He argues that this process allows for adaptation and

adjustment of the program or project and for learning and growth.

This also includes evaluative processes – developmental evaluation as defined by Patton. Patton (2011, p. 20) describes developmental evaluation (as distinct from development evaluation) as a process in which the program or project and the evaluation (and the researcher and evaluator) are not distinct and separate but are working together combining evaluation and ongoing project development, adaptation and implementation; adapting effective principles to a new context, developing rapid responses to change or crisis.

This concept of evolutionary learning is roughly similar to what Argyris describes as triple-loop learning (learning how to learn). Argyris and Schon (1978) describe three levels of learning, where learning is the detection and correction of error. In single-loop learning, the unspoken assumptions and norms are not questioned and learning happens within these parameters. However, in double loop learning, these underlying norms, assumptions and knowledge are up for questioning and the rules are changed (1977, p. 116). Argyris uses the example of organisational learning, in which the difficult decision by a company to discontinue a problematic product creates a double bind in which employees have to deal with an unspoken norm that suggest that errors should be hidden, and another which suggests errors should be revealed. In order to constructively deal with this problem the employees have to confront this double bind. One of the tensions emerging here is the tug between the individual and the group.

Romme and Witteloostuijn (1999) go a step beyond this to describe triple-loop learning which “manifests itself in the form of ‘collective mindfulness’” (1999, p. 440), and is about learning how to learn. Romme and Witteloostuijn equate this with Bateson’s concept of deutero-learning.

Bateson developed the notion of deutero-learning and the double bind. Deutero-learning is the third of four levels of learning processes which he described as “learning to learn” or learning II (Visser, 2003, p. 275). Bateson developed double bind theory in which the learning being or organism is subjected to a situation where it cannot learn the required behaviour, but is forced to create new behaviours. Bateson uses the example of a child which is punished for yelling, but then punished for learning that yelling is punished. While the idea of the double bind was originally conceived in a psychology context, it

has been used more widely, particularly (but not only) in relation to complex systems thinking.

This tension between opposing or contradictory perspectives and the potential for new thinking and solutions as a result, is a central concept in this thesis. I have explored this idea of tension from a number of perspectives, of which the double bind is just one. In addition, I explore the concept of dualisms, dichotomies, paradoxes and pattern conflicts.

A dualism is defined by the Australian Macquarie Dictionary as "the state of being dual, or consisting of two parts" and "a theory holding that there are two, and only two, basic and irreducible principles, such as mind and body". The idea of dualisms was explored by John Dewey, whose goal was to "reconstruct" a series of dualisms as continuous rather than dichotomous (meaning divided into two parts). One of his best known examples is his presentation of habit, impulse (or instinct) and intelligence and the recursive relationship (or continuous loop) between them (Ansell, 2011, p. 123). He suggests that habit is the "third term" which mediates between impulse and intelligence, and sees habit as "the missing term in a dualism that pits the primacy of instinct against the primacy of reason" (Ansell, 2011, p. 124).

This is also called the "principle of the included middle" by Manfred Max-Neef (2005), who quotes Niels Bohr's motto "contraria sunt complementa" which means opposites are complementary. According to classical Aristotelian logic, pairs of contradictories (such as particle and wave theory) are mutually exclusive, according to the three axioms, which are the axioms of identity, non-contradiction and of the excluded middle. The axiom of the included middle by contrast is identified by Max-Neef as the "logic of transdisciplinarity and complexity, since it allows, through an iterative process, to cross different areas of knowledge in a coherent manner and generate a new simplicity" (Max-Neef, 2005, p. 13).

The logic of the included middle is analogous to the "third or mediating term" as described above by Ansell (2011) and other anti-dualists. Max-Neef clearly states why this is so important. It allows for an iterative and coherent transition across seemingly

incompatible realities or “sets” of knowledge to create new knowledge and new open (and incomplete) rounds of theory and practice. This process is iterative and infinite as each new insight generates new contradictions and hence the potential for transformation of knowledge and action.

While for some, this may be dispiriting (with no final certainty at the end), for others it opens up an endless and exciting vista of new knowledge, epistemological framings and exciting, novel solutions to seemingly intractable problems. This is the heartland of what Max-Neef calls “strong transdisciplinarity” (Max-Neef, 2005).

The concepts of evolutionary learning and the included middle or double bind are crucial to my study – the idea of different, or even opposing orders of things is a central concept for one of the three analytical frameworks I have used here. In the case of Ansell and other Pragmatists, such as Dewey, Garrison, and Vanderstraeten (in Ansell, 2011), this is described as “yoking together opposing orders in creative tension” (2011, p. 10). Dewey called this a “transaction”, and Ansell calls it “the triadic dimension”.

Double binds, dualisms, dichotomies and paradoxes

These two premises, that learning is cyclic (and incorporates experience) and the need for the creative tension to open up new opportunities, have been discussed by various theorists and expressed in different ways. They are particularly important in the context of transdisciplinary research to solve wicked problems in complex systems. Problem solving in wicked problems can only occur iteratively, as there is no stopping rule, nor are there any final solutions, but rather a series of partial ongoing solutions. In a transdisciplinary team (going beyond disciplinarity), diversity of world-views and interpretations and paradox are not only inevitable, but necessary for innovative problem solving.

The creative tension is the crucial element here, and Ansell recommends three ways to create this. Firstly, by emphasising the continuousness of the phenomena (that there is no boundary between opposing elements), and secondly, by insisting on a tight coupling between meaning and action. But most important for this study, is Ansell’s recommendation to set up a triadic or third dimension (or mediated relationship between opposing elements), instead of prioritising one end of a dualism at the expense of the

other (2011, p. 10).

Kolb echoes this, stating "… learning is best facilitated in an environment where there is dialectic tension and conflict between immediate, concrete experience and analytical detachment" (1984, p. 9) which is just one example of a constructed dualism. Similarly, Dewey says, "… there is an intimate and necessary relation between the processes of actual experience and education" (Dewey, 1938, p. 19–20; in Kolb, 1984, p. 5).

Ansell describes Dewey's work in seeking to overcome a series of dualisms which he perceived to be "poisoning modern thought and life" (2011, p. 122). Dewey included the following dualisms in his list: individual and society; subject and object; mind and body; thought and action; and reason and emotion among others. Dewey primarily relied on recursiveness as a technique to overcome dualism. The third dimension, created between seeming polar opposites or paradoxes, is described by Dewey as a "transaction" (Ansell, 2011). Brown and Harris describe this as the "third space … and this space is one of the drivers for transformational change" (Brown & Harris, 2014, p. 81).

Brown & Harris use the perspective of a paradox, which is "a statement or proposition seemingly self-contradictory or absurd, and yet explicable as expressing a truth" according to the Australian Macquarie Dictionary. They describe the reorientation and dissolving of seeming paradoxes through collective thinking. They describe four seeming paradoxes created through the binary thinking of the Enlightenment. These include parts and wholes, stability and chaos, individuals and society, and creativity and rationality (Brown & Harris, 2014). Brown and Harris posit that collective thinking is a way not just to move away from the idea of dividing or opposing paradoxes, but a way to embrace the creative potential of the third space. Again the common theme is the tension generated by the seeming paradoxes and the potential to generate new thinking and approaches.

Kurt Lewin describes the tension between the seemingly opposite approaches to learning of rational thinking and analytical detachment on the one hand, and immediate, concrete experience on the other (Kolb, 1984). In his work on group dynamics, Lewin

discovered the dialectic tension and conflict between these two resulted in a remarkably vital creative and productive learning environment (Kolb, 1984). The separation between concrete (measurable) experience, and abstract thinking (as well as the separation between rational and creative thinking) is relatively recent, and was part of the transformation that was the Enlightenment in the 17th century (Brown & Harris, 2014). Funtowitz and Ravetz also talk about the traditional (post-Enlightenment) domination of "hard facts" over "soft values" being inverted in post-normal science problem-solving, and that these two bi-polar categories can no longer be usefully separated but form a triadic logic (1994, p. 1884).

As discussed in the previous section, this creative tension between rational thinking and concrete experience is the basis of a number of learning models. Kolb describes experiential learning as a cyclical process with four recurring stages of learning. These are concrete experience, reflective observation, abstract conceptualisation and active experimentation.

As described previously, Ansell talks about three generative conditions for learning, which are problem-driven perspective, reflexivity and deliberation. He writes about recursiveness as a "continuous and interlocking cycle of perspectives", and the importance of the tension or "tug-of-war" between seeming opposites (such as between freedom and constraint, centralisation and decentralisation). He provides specific examples including cosmopolitan localism, analytical holism, progressive conservativism and processual structuralism, which for him shape constructive problem-solving, reflexivity and deliberation (Ansell, 2011, p. 104 & 187).

Westley et al. (2006) link this kind of learning and the triadic logic to complexity theory in social innovation. They suggest that the instigators of social change in their case studies were not necessarily "leading the troops like generals on their horses" (Westley et al., 2006, loc. 681 of 3998), but were instead catalysing a new pattern of interactions. That they were acting as "strange attractors", an analogy from chaos theory. According to chaos theory, while an attractor holds a system in the current pattern, a strange attractor disrupts these patterns. They further assert that rather than instigating a planned set of changes, they catalyse a series of iterative or recursive learning and change and are themselves changed in the process.

Westley et al. (2006) highlight another paradox in social innovation in complex systems: that while we are not free from responsibility for social change and engagement, we are also not able to attribute successful change to ourselves (or others) nor can we escape being changed ourselves. They suggest that strange attractors are held together in paradox, including profound uncertainty and deep understanding; self-protection and vulnerability; and changing others by changing oneself. They talk about two perspectives meeting in tension – intentionality and complexity. Given that complexity science describes unpredictable emergence, how can we change things deliberately and intentionally?

Westley et al. explain the title of their book *Getting to maybe* thus: "We think that getting to maybe is the best we can do … Just as social innovation holds thought and action in tension, and complexity theory … balances intention and unpredictability, the word 'maybe' combines two ideas and holds them in tension." (2006, loc. 487 of 3998).

C.P. Snow, in the Rede lecture *The Two Cultures and the scientific literature* talks about "moving regularly from one to the other and back again" (p. 2, 1959) in a dualistic world between the scientists (since he is a scientist) and the literary world (since he is also a writer).

> I was moving among two groups-comparable in intelligence, identical in race, not grossly different in social origin, earning about the same incomes, who had almost ceased to communicate at all, who in intellectual, moral and psychological climate had so little in common that instead of going from Burlington House or South Kensington to Chelsea, one might have crossed an ocean. (Snow, 1958, p. 2)

He was increasingly concerned about the separation and polarisation of these two groups – the scientific and literary – particularly as he successfully (and clearly challengingly) belonged to both.

Byrne and Callaghan assert an absolute requirement for viewing the world through a complexity framework to transcend the artificial separation of the "hard" and "human" sciences in the face of potential anthropogenic ecological disaster (2014, p. 244).

Nowotny et al. go further, suggesting that modernist science was predicated on a series of Cartesian dualisms or the construction of a bi-polar world, including mind and body, right and wrong, good and evil, rational and irrational, and modern and pre-modern, and starkly illustrated by the dualistic nature of the Cold War (2001, p. 6, loc. 180 of 6105).

Dealing with multiple ways of knowing

The final source of tension I discuss here is that of pattern mismatch or pattern conflict. I use this as a stipulative definition to broadly cover a range of concepts that describe differences in knowledge cultures, paradigm or worldview.

World-view is a broadly used term, which I describe here as our individual understanding of the world based on lived experience; cultural and geographical situation and influences; social influences and communities of practice; with strong overtones of power relations and asymmetries (Naugle, 2002; Sire, 2004).

Describing knowledge differences and cultures is no easy matter. Brown (2008) outlines five socially constructed knowledge cultures in Western society of which we are all a part, and from which we derive our own knowledge and world-view. They are individual, local, specialist, institutional and holistic. Individual is that of our own unique experience and existence; local that of the various locally situated groups we are part of (e.g. family, village, school etc.); specialist includes the knowledge we gain in professional, vocational or disciplinary groups; and institutional is that of our workplace and the various other institutions we are part of through our lives. Holistic is that which combines all of the above.

In Western culture and within its influence we each learn and generate knowledge from all five of these cultures (Brown, 2008), but Western thinking has created a hierarchy where not all knowledge is equal. Institutional or organisational knowledge trumps specialist knowledge, which trumps local or community knowledge which trumps individual knowledge. Holistic knowledge is often disregarded or dismissed as “wishy-washy”.

Underlying world-views and different kinds of knowledge are power asymmetries, and different kinds of knowledge holding different status and power. This raises questions

about the idea of truth as objective reality, and suggests that different world-views or kinds of knowledge are discourses whose objective is a play for power (Foucault, 1991; Sire, 2004).

Stepping beyond Western culture shows more compartmentalisation and hierarchy. Santos et al. say that despite the growing awareness of cultural diversity in the world, there is not a corresponding awareness or understanding of the epistemological diversity which is the diversity of knowledge systems (2008, p. Xix). They take this further, saying that modern Western Enlightenment science has been privileged or empowered to the point where not only has it enabled technological revolutions, but it has suppressed other ways of constructing knowledge, including other culture, disciplines, and the knowledge of practitioners.

This is a particular challenge in research for development, which has for much of its history been predicated on technological superiority of Western science, and has often focused on "knowledge transfer", assuming that Western knowledge and science will be the answer to the problems of less-developed countries (Santos et al., 2008). Therefore, issues of power are a central issue in bringing together different kinds of knowledge.

It is clear from this that knowledge mismatches are likely to be frequent, particularly in transdisciplinary research, international development arenas and in complex "wicked" societal problem solving. Rather than seeing this as a constraint and a problem, it can be another source of creative tension and new thinking.

Using tension in a constructive and creative way

While bringing opposites together results in a creative tension, there needs to be a mechanism for dialogue and collective thinking to exploit and act on this. This is important in this thesis, given that the case study research projects are transdisciplinary rural research for development in complex, wicked problem situations. For example, seemingly incompatible disciplinary (and non-disciplinary) groups (with vastly different worldviews) have been brought together for collective problem solving. In addition, there is the need to find solutions not only for individual beneficiaries but also for their

communities and societies. Through the participatory approaches used in research, practical experience and abstract rationality have been brought together, and "organic" even chaotic approaches have been implemented alongside ordered and log-framed approaches to research.

From the donor perspective, there is a demand for clear, linear statements of outputs and outcomes in the face of unpredictability, uncertainty and unknowns and a highly complex reality. The point of this study is to see these contradictions as useful rather than an impediment. That such paradoxical situations should lead to a creative tension which can drive, not only innovation, but collective and transformative thinking.

In the previous two sections I have outlined a slightly daunting array of sources of tension, including paradoxes, dualisms, dichotomies and pattern mismatches. The sources and descriptions of this tension are too numerous to form a useful pattern set or analytical tool, so I have summarised them, using the set suggested by Brown and Harris (2014). Brown and Harris suggest that for collective and transformative thinking to occur there are four preconditions that must be recognised. Firstly, in any dynamic system, everything is both part and whole. Secondly, stability and chaos exist in living systems at the same time. Thirdly, that the tension between individuals and society is the "third space" or third dimension. This third dimension is a creative space for collective learning and community. Finally, that human thought is both rational and creative at the same time (2014, p. 203). I use these four preconditions as the pattern set for investigating the existing and potential creative tension in the case study projects in this thesis research.

Parts and wholes

Every research journey is an individual learning journey in its own right, as well as a social or collective learning journey from a project perspective. In such a dynamic system "everything is a part and a whole" (Brown & Harris, 2014, p. 203). For example, every individual researcher influences their colleagues but at the same time they are undertaking individual journeys. My inquiry therefore includes the study of both individual researchers and their project team.

Stability and chaos

The project briefs given by funding agencies generally ask for a predictable outcome and linear process. In the previous chapter, I refer to the tension between the need to structure and organise research, and the complexity and seeming chaos of bringing together multiple ways of thinking, research approaches and world-views, suggesting that the tension between order and chaos lies at the heart of strong transdisciplinary research practice. Crutchfield (2003) talks about the dynamic interplay between order and chaos as the place where complex systems evolve and learn through interaction with their environment.

Creativity and rationality

The basis of Enlightenment thinking was the separation of creativity and rationality. And the pretence is that we use either one or the other. But they are inseparable in human thought (Kolb, 1984). The question of whether they have been separated and how and whether they can be brought back together has been argued by C.P. Snow in his "two cultures", and by Isaiah Berlin (2000). Similarly, the Pragmatists talked about the need to bring together concrete experience, reflection, abstract rationality and active experimentation to create learning.

Individuals and society

There are many examples of individuals and society including researchers and research teams, farmers and farming communities, farming communities and provincial/national systems, national and international systems. All interact and produce tensions. For example, while we act as individuals, our experience and our learning is socially constructed.

Bastardas-Boada suggests that bringing together these seeming paradoxes is one of the "profound changes we need to address from the epistemological perspective of complexics" (2014, p. 5). He quotes Norbert Elias;

> We talk of the person and his environment, a child and his family, the individual

> and society, the subject and objects without always realising that the person also forms a part of his "environment", the child is part of his family, the individual is part of society, the subject is part of the objects. (…) But our language and our concepts are largely set up as if everything that is outside of the individual person had the character of static objects. Concepts like "family" and "school" typically refer to a group of people. But our usual kinds of terminological and conceptual configurations make them sound as if they were objects of the same nature as rocks, trees or houses. (Elias, 1982, p. 14 in Bastardas-Boada, 2014, p. 6)

Bastardas-Boada also quotes Morin as follows:

> Individuals are not in society in a box. There are interactions among individuals that produce society, which never exist without the individuals. (…) … We produce a society that produces us. We are part of the society that is part of us. (Morin, 1994, p. 304–305 in Bastardas-Boada, 2104, p. 6)

Max-Neef describes Edgar Morin's proposal to develop recursive thinking "capable of establishing feedback loops in terms of concepts such as whole/part, order/disorder, observer/observed, system/ecosystem, in such a way that they remain simultaneously complementary and antagonistic" (Morin, 1992, in Max-Neef, 2005, p. 14). Hence, in this thesis, I have adopted recursiveness as not only one of the key tenets of evolutionary learning, but also in terms of dealing with sets of seeming paradoxes or dualism to discover new and novel solutions and answers to questions posed to tackle complex systems issues.

From social to collective learning

Having explored the nature of paradox, double binds and other sources of tension, I explore constructive ways in which different worldviews and approaches can be brought together as a collective for transdisciplinary inquiry and problem solving, and to address the challenge of pattern mismatches and open ways for those with differing world-views to understand each other.

In describing a theory of collective learning, Kilgore creates a vivid account of this as follows:

> It is the order that arises from chaos. It is the definition that we seek – not only for ourselves, but for the group in which we are interested – that emerges from the complexity of our differences. A theory of collective learning emphasises difference, and opens the way from reductionist definitions of groups towards more detailed and rich understandings.
>
> (Kilgore, 1999, p. 191)

Brown and Harris talk about collective thinking (as a component of social learning) as requiring openness and versatility of the individuals involved, as well as a diversity of individual thinking in the group (2014, p. 9). They specifically talk about collective thinking and collective learning across a broad range of knowledge cultures, communities of practice and ways of knowing. In this case the collective learning is necessarily broader than the sum of individual learning and a change in beliefs and assumptions can be said to have occurred.

Brown and Harris' (2014) claim that all humans understand the world through seven ways of understanding or seven questions, which I will call here domains of understanding or ways of knowing. For collective learning or thinking to occur, requires two separate processes – individual learning and learning by the group, which encompasses all seven of the domains of human understanding (introspective, physical, social, ethical, aesthetic, sympathetic and reflective).

Other similar ideas and approaches include Gardner's (2006) idea of seven intelligences, and Jones et al. (2012) posit three broad types of knowledge – research-based, practice-informed and citizen knowledge, with four key "content" areas (descriptive, explanatory, normative and subjective). Gardner's (2006) seven intelligences are musical, bodily-kinesthetic, logical- mathematical, linguistic, spatial, interpersonal and intrapersonal (though he has suggested that there may be others). Vincent (2012), in the context of addressing HIV prevention, talks about the need to address broader "structural" social and contextual factors which he lists as social, economic, political, cultural and environmental. While these examples are useful ways to think about knowledge and knowing, they do not provide the coupling of questions and evidence – which is suggested by Brown and Harris (2014) in their seven questions.

Five doorways to human understanding

While everyone has access to all seven ways of thinking, Brown and Harris posit that each of us (both individually and as part of our various knowledge cultures) favour particular domains of thinking over others. Since the Enlightenment, for example, the physical (with the social in second place) has been privileged over the rest. In addition, social questions have been approached from a largely empirical perspective, with quantitative measurement being the currency of validity and rigour or reliable knowledge (Nowotny et al., 2001).

In looking at the domains of human understanding, it is important not to regard them as discrete and independent entities and concepts. They weave and link into each other through the process of human thinking and deliberation. Hocking et al. phrase this beautifully using a metaphor.

> The questions are like multiple doors to understanding, any one of which opens onto all the others. All seven combine to make up human understanding. Everyone has access to and uses all these seven ways. However, in our specialised world, often we enter through a particular door, one of the seven, and it is from this perspective that we access the other six. (Hocking et al, 2015, p. 7–8)

Hocking et al. go on to say that "dwelling in one doorway" to the exclusion of others is limiting, using the example of exclusively aesthetic or physical view of design (2015, p. 8). Neither design from a purely physical perspective (e.g. the skills of an engineer) or from a purely aesthetic perspective (relying exclusively on an idea of beauty) will deliver a satisfactory building or home.

Brown and Harris (2014) propose the application of the questions (according to the seven domains of human understanding) as a way to make cultural, disciplinary and epistemological barriers permeable in order to bring about collective learning. The seven domains of understanding (or seven questions) can be roughly divided into internally-focused (introspective and reflective) and externally-focused thinking (physical, social, ethical, sympathetic and aesthetic).

I have focused here on Brown and Harris' five externally-focused questions, which I call the doorways or lenses (physical, social, ethical, aesthetic and sympathetic) for human understanding. (The remaining two "doorways" or "questions" are introspection and reflection, which I discuss separately at the end of this chapter.) I use these doorways as one of the pattern sets in my inquiry, to investigate the latent knowledge and experience of the research participants, particularly those aspects which are not captured in formal research documentation.

I investigate these doorways or lenses as a means to overcome the divisions in thinking and problems solving between different disciplines, knowledge cultures or worldviews. The doorways or lenses do not map to disciplines (be they sciences or humanities) but sit beyond disciplines, and include ways of knowing outside academia including practitioner and policy knowledge. In addition, I see this as a means to invoke the inventiveness, experience and insight of those involved (Scott, 1998, p. 377). Using the metaphor of doorways is also useful from the perspective of social innovation in complex systems.

> Social innovators are not people who create more doors, or even people who are surrounded by more doors than other folks. They are simply people who see more doors. They believe in doors, if you will, and so doors are there. (Westley et al., 2006)

One of the key reasons to include all of these doorways to understanding is to provide a means to work constructively with complexity and to encourage engagement with greater diversity and options and avenues for constructive change. In particular, this is a way to avoid reducing a complex system and isolating it into component parts which denies the nature of organised complexity and limits the possibilities for change and innovation. Fenwick et al. emphasise the importance of focusing on the socio-material and avoiding the false separation between the social and material reality (Fenwick, 2012; Fenwick & Landri, 2012; Fenwick et al., 2011). Klein also places ethics, aesthetics and creativity within disciplinary and professional work, as a means to incorporate the social and political, as well as normative and ethical questions (2014, p. 73). In discussing Mode 2 science and knowledge creation, Nowotny et al. emphasise

the need to focus on “socially robust knowledge” rather than “reliable scientific knowledge” as expertise becomes more socially distributed and heterogeneous (2001).

The physical doorway to understanding

The physical doorway to understanding the external world generates questions about the material world and the evidence of the senses answered through measurement and observation. It includes things that can be measured, counted, visualised and observed. The Enlightenment has brought the physical doorway to understanding to the fore, almost to the exclusion of the others. Berlin, in his essay “The Divorce between the sciences and the humanities” delves into the history of Enlightenment thinking. He observes that the Enlightenment scientific approach rests on three assumptions. Firstly, that every question has one true answer and all other answers are false. Secondly, that only “rational” methods will lead to correct solutions, and thirdly, that these answers are universally true at all times and in all places. By extension, there is only one valid set of methods or combination of methods and the world is a single unified system of all the sciences, natural and human (2001, p. 334–335).

This reliance on empirical, rational, so-called objective approaches (particularly the mathematical and physical sciences) has underpinned the technological success of the Enlightenment and, in the early stages, freed thinkers from the shackles of dogma, faith and prescription. However, as Berlin (2000) points out, this has been achieved often at the expense of other ways of thinking. The physical is the domain of that which is tangible and is about things that can be seen and touched. It is important not to confuse the physical domain of thinking with all things quantitative. Quantitative measurement has also been the predominant form for the social domain of thinking in recent history.

The social doorway to understanding

A good example of the social doorway to understanding is our over-reliance on classical economics as the primary (and in some cases the only) measure or means on which to base policy and other decisions. While economics is a very useful tool, to use it alone is to downgrade or ignore other considerations such as ethical, aesthetic and sympathetic (and even physical) ways of thinking and knowing. But while much of the economics we see and hear about is quantitative, it is essentially social in that it is based on

abstractions and social constructs. For example, money is a social construct, and a pile of banknotes is a physical "thing".

The questions generated through the social doorway to understanding come from the lived experience of the community and individuals and include language, images, metaphors, narratives, myths, symbols, behaviours and beliefs. Since the Enlightenment period, the social doorway to human thinking has generally been regarded as a lesser way of knowing than the physical. The social question can be confusing and does not simply equate to what we now call social science. Many aspects of social science are quite empirical and quantitative in nature, for example the psychological sciences and many aspects of sociology. For example, a demographic survey is an example of physical measurement rather than a social query.

The stumbling blocks for the distinction between physical and social are important to note and crucial for collective inquiry. There is a tendency to conflate the social and physical, in particular to reify social ideas or concepts (such as money) as "real" physical things. It is also important to remember that the social is not a matter of objectivity, as it reflects lived experience and social ideas and constructs.

Knowledge production is itself a social process, and "co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it … society cannot function without knowledge any more than knowledge can exist without appropriate social supports" (Jasanoff, 2006, p. 2). She goes on to say that, in Western contexts, scientific knowledge is "embedded in social practices, identities, norms, conventions, discourses, instruments and institutions – in short all the building blocks of what we call social" (Jasanoff, 2006, p. 3).

The ethical doorway to understanding

The ethical mode or doorway to understanding is less often discussed, and includes ideals, principles, aims and standards of good and evil. This domain of human understanding underpins our social networks, informing social rules and standards and

including concepts such as honesty, justice, equity, dignity and self-determination. It is an examination of the principles and ways in which humans relate to each other (Berlin, 2000, p. 1).

> … [Ethics is about] the conceptions, interests and ideals from which human ways of treating one another spring, and the systems of value on which such ends of life are based. These beliefs about how life should be lived, what men and women should be and do, are objects of moral enquiry; and when applied to groups and nationals, and, indeed, mankind as a whole are called political philosophy, which is but ethics applied to society. (Berlin, 2000, p. 1)

Based on Berlin's account of ethics, public policy is significantly influenced by the ethical domain of human understanding and must include an ethical standpoint. This is in contrast to some current assertions that policy is ethically neutral, and that science is ethically neutral as well. This is particularly important given that the kind of research problems discussed here are inevitably wicked problems, and hence political, and scientific or techno-rational planning will simply not suffice nor does it reflect or deal with power asymmetries (Rittel, 1972, p. 394; Scott, 1998, p. 374). There are also specific ethical considerations in research, including what is called "human ethics", and which researchers are now routinely required to take into account, and gain approval for from their research institutes. The development principle of "doing no harm" comes under this category, and is far less simple than it may seem, given that harm can be done quite unintentionally or unknowingly, and usually with the best intentions and a genuine desire to improve the human condition (Scott, 1998, p. 374). With a broad range of viewpoints and worldviews in a team or group, the ethical question can be far more thoroughly considered from various perspectives and viewpoints, but is often not explicitly discussed in research design or implementation in my experience.

Max-Neef (drawing on Jantsch (1970) puts ethics, values and philosophy at the top of the four levels of his pyramid of transdisciplinarity (which are empirical, purposive or pragmatic, normative and values), and argues that this level is frequently ignored or invisible. He give the example of economics being taught as a value-free science and he argues that no science is value-free, that instead the normative level (which includes politics, planning, design and law) tends to dominate and silence debate and questions about values and potential differences in values (2005).

Nowotny et al. (2001) talk about the rise of Mode 2 society (a follow-on from the concept of Mode 2 science) and the inevitable increase in differentiation, volatility and uncertainty which also results in less equality, and more diverse forms of inequality and injustice. Including the ethical domain of human understanding in inquiry means that it is less easy to side-step these tricky issues or to either disregard or simply be unaware of them.

The aesthetic doorway to understanding

The aesthetic question includes designs, visions, and concepts of beauty and ugliness. This is the question that goes to the heart of human creativity and is a "springboard" for new thinking. Concepts such as designs, visions, standards of beauty and ugliness are the currency for this set of answers. What is considered beautiful, ugly, elegant, tasteful, stylish etc. has varied enormously through history. Umberto Eco in "History of Beauty" documents various conceptions and accounts of beauty and aesthetics from the ancient Greeks through to contemporary times, in which he describes the "total syncretism and the absolute and unstoppable polytheism of Beauty" (Eco, 2004, p. 428). He thus acknowledges that, even now, notions of beauty vary according to culture, community, individual tastes and even disciplines.

Aesthetics is important from a number of perspectives, including evoking feelings such as well-being, happiness, joy, hope, sadness or despair – all essentially human experiences. A vivid example is Charles Dickens' grim, joyless account of Cokeville (an Industrial Revolution town in the novel "Hard Times") in which he describes red brick, black smoke and ashes dominating the town:

> … containing several large streets all very like one another, and many small streets still more like one another, inhabited by people equally like one another, who all went in and out at the same hour, with the same sound upon the same pavements, to do the same work, and to whom every day was the same as yesterday and tomorrow, and every year the counterpart of the last and the next" (Dickens, 1954 in Eco, 2004, p. 329)

This depressing vision presented by Dickens is echoed in Scott's description of the

potential outcomes of restricting the kind of questions asked in the process of development planning. “Questions about the volume of commercial wood or the yield of wheat in bushels permit more precise calculations than questions about, say, the quality of the soil, the versatility and taste of the grain, or the well-being of the community.” (Scott, 1998, p. 377). Scott gives a number of examples of high modernist development and social engineering schemes, including the disastrous results of the techno-rational construction of the city of Brasilia.

Aesthetics is often equated with the various forms of creative arts, but Melchionne points to the importance of everyday aesthetics in promoting subjective well-being and equates it to practice. His five examples of everyday aesthetic practice are food preparation, choosing one’s wardrobe, dwelling, conviviality and going out. He defines well-being as arising when individuals have a steady flow of positive feelings outweighing negative ones, satisfaction with their main pursuits and are generally positive in their evaluation of their lives (2014, p. 2). He suggests that well-being promotes creativity and exploration and a great ability to deal with challenges, and he equates this with what is called “emotional intelligence”. Aesthetics is predominantly about the sensory and is often strongly linked with patterns and recognition of patterns (Alexander, 1977). It is also strongly linked to subjectivity and creativity.

While the aesthetic sense influences human experience so graphically, it is also a doorway for creative and intuitive leaps – those hyperspace jumps of knowing and learning that human minds are capable of, but which cannot be easily unravelled into a series of steps or signposts.

I suggest that the aesthetic sense is a key doorway or lens through which to identify patterns. Recognising patterns and their recurrence is a key strategy for dealing with wicked problems and highly complex systems. Rather than trying to identify the parts and build the whole, instead focus on the patterns.

The sympathetic doorway to understanding

The sympathetic way of knowing is about relationships and relating and can only be answered through an emotional connection to the people (or other beings or things) involved. Questions and evidence for this way of knowing relate to feelings/emotions,

relationships, trust, sense of others, leadership, conflict, friendship and so on. In his theory of (seven) multiple intelligences, Gardner's interpersonal intelligence focuses on a person's capacity to connect with another person to detect mood, temperament, motivation and intentions, and changes or distinctions in these. He uses the example of religious and political leaders, teachers, salespersons, therapists and parents as having advanced ability in this area (2006, p. 20). What he doesn't highlight is that each of these have this connection with a particular other person or group of people.

This is a critical part of transdisciplinary practice. In bringing together so many different worldviews, disciplines, and ways of thinking, relationships and relating are essential to establish a bond or sense of a team, particularly when disagreements, controversies and messes will inevitably arise. Bringing together this broad range of human and non-human sympathetic connections and ways of knowing in a transdisciplinary project creates a complex network of relationships and understandings.

Kilgore highlights the importance of relationships in collective social action rather than a common set of beliefs. For example, the most effective recruiting efforts by social movement organisations is from existing members' friends (1999, p. 195). This domain of human understanding is much more than about relationships and relating between people. It also includes the sympathetic mode of thinking about things, land, and creatures. For example, a farmer or other land manager may use the sympathetic domain of understanding in relation to their land or their animals.

Crossley suggests that, rather than getting caught up in the debate about whether to look at individuals or society as a whole (or parts and wholes), a more appropriate way to study social life is through the various networks of relationships and interactions (2011, p. 2). Crossley posits social life as a set of overlapping worlds based around shared interests and activities and the dynamics of the interactions within these (Crossley, 2010 in Vincent, 2012, p. 9), highlighting that individuals are generally part of a number of different relational networks with implications for relational power and flow of resources among other things, and a crucial component of studying development and change.

The sympathetic way of knowing is about relationships between people and people, and between people and things. Asking questions and forming knowledge about this is essential in research – particularly research for development – which is about social change.

Finally, the sympathetic lens or doorway lends itself to the study of complex systems. According to Westley et al., (2006) complex systems cannot be understood by studying the parts, but rather by studying the relationships between the parts. The sympathetic doorway to understanding includes lived experience, networks, relationships and relating.

Reflection and reflexivity

Bringing together all the five doorways to understanding is the process of reflection and reflexivity. Reflection and reflexivity occur both individually and as a group (the research team in this case). However, talking about both reflection and reflexivity is a means of including different levels of reflection, as described by Salas-Zapata (2013). In outlining key challenges for addressing complex sustainability problems, Popa et al. talk about the lack of emphasis on "reflexive questioning around values, background assumptions and normative orientations of various approaches to sustainability in transdisciplinary research" (2015, p. 46) and place reflexivity at the core of transdisciplinarity practice. They describe one of the roles of reflexivity as facilitating "open-ended processes of inquiry geared towards a broadening of the community of practice through social innovation and experimentation" (Popa et al., 2014, p. 48). They recommend a more systematic integration of reflexivity as a means of avoiding what they term "unstructured pluralism" where diverse views, assumption and knowledge come together in transdisciplinary research through multiple disciplinary and non-disciplinary participation.

Armson describes the process of reflexivity as "a shared space where you and I stand, reflecting in our own mirrors on our own experience" (2011, loc. 145 of 8127). She goes on to highlight the importance of reflexivity, saying "… we are not separate from our own perspective. We do not have access to an objective view because none of us is separate from our histories, our accumulated experience, our own interests and our

habitual ways of observing" (Armson, 2011, loc. 2758 of 8127).

In particular, Popa et al., recommend a pragmatist approach, "rooted in a collaborative process of concrete problem-solving in which participants are led to question and jointly reframe their values and understandings" (2014, p. 48). They highlight four characteristic aspects of reflexivity:

1. Collaborative deliberation to develop shared understanding of a problem.
2. The social relevance of the problem framing.
3. Social experimentation and collective learning processes.
4. Critical and transformative nature of the research agenda.

These four span the research project lifecycle, including problem formulation, the process of inquiry and evaluative process, weaving reflexivity throughout the project lifecycle, and as an integral part of transdisciplinary research practice.

In seeking a set of core principles for sustainability science and the operationalisation of transdisciplinarity, Salas-Zapata et al. (2013) develop a typology of reflection (which could also be regarded as a hierarchy), which navigates between the need to construct concepts and theories, as well as the need for practical, concrete solutions. The lowest level is practical reflection, which I argue is familiar territory for most researchers, and is about the questions relating to real and practical situations and the data and insights generated through the process of inquiry. At the next level up, Salas-Zapata et al. (2013) propose instrumental-methodological reflection that focuses on the tools or methods needed to investigate research problems. I argue that this is also a commonplace form of reflection, and an integral part of research design.

This is followed by theoretical-conceptual reflection, which links theoretical structures to the real-world problems. At the top of the hierarchy is onto-epistemological reflection which gets to the nub of how the researchers understand the world and the worldview they are applying to the research problem (Salas-Zapata et al., 2013). For the purposes of this thesis, I broadly group the latter two as reflexivity as they require self-examination and understanding, particularly of putting the self in the research context and understanding how one understands and interprets the world.

There is a broad literature on reflection spanning many disciplines and fields, having no academic core, but spanning disciplinary boundaries. This includes critical reflection, reflective practice, reflexivity, experiential learning and transformational learning (Fook & Gardner, 2007, p. 13). Fook and Gardner focus on critical reflection. They propose critical reflection as an inclusive idea that can be applied flexibly to a range of situations, but providing the ability to unsettle settled ideas and question taken-for-granted assumptions (2007, p.14).

I equate reflexivity broadly (again for the purposes of this thesis) with Brown and Harris' concept of introspection, which examines the foundations of personal thinking including identity, experience, assumptions and context seen through the other five "doorways" or domains. The answers to the introspective question are what the individual brings to the team or group and the project context, and are about self-reflection or reflexivity. This is the essential understanding of self – the assumptions, experience, history and identity that each of us has. Santos sees self-reflexivity as the "first step towards the recognition of the epistemological diversity of the world" (2008, p. xxi), or seeing oneself and one's own knowledge system in a context of diversity and multiplicity. Reflexivity is also the ability to recognise that the way we create knowledge (including through research) is influenced by all aspects of ourselves and our history and contexts, and that "knowledge creation is embodied, social, reactive and interactional" (Fook & Gardner, 2007, p. 31).

Critical reflection provides a means to link individuals and society, the rational and creative, parts and wholes and stability and change – in effect to bring together the dynamic and paradoxical connections of the synergistic, stochastic, developmental and holistic to call into question individual and social assumptions to make room for transformational change (Fook & Gardner, 2007; Brown & Harris, 2014).

The last component to consider is that of collective reflection among the research participants. This is absolutely crucial in a complex systems and wicked problem setting, as it provides a means to establish a constructive and productive dialogue around the conflicting worldviews, perspectives and preferences of the various disciplines, non-disciplines and individuals.

For the purposes of this thesis, I have adapted Salas-Zapata et al. (2013) typology of

reflection as a means to more closely examine the approaches, levels and effectiveness of reflection in the context of ongoing and iterative research monitoring, evaluation and design. I have modified the original typology to reflect the perspectives from the case study projects and to reflect the conceptions of Fook and Gardner (2007), Brown and Harris (2014) and Popa et al. (2014).

The four levels of reflection in this typology, and some characteristic questions asked of oneself and the collective group are:

1. **Practical reflection**: This level is about reflection on the practical aspects of the research, data interpretation, problem-diagnosis and solution and includes questions such as: What do these results mean? What does this tell me? What are the implications? Why is this important?
2. **Instrumental reflection**: What tools or methods are appropriate to answer the research questions posed? What does validity, rigour or relevance mean here? What are the options available to answer the research questions and how effective are they?
3. **Theoretical-conceptual reflection**: What theoretical or conceptual framing will help inform the research? Am I looking at best fit or best practice? What kind of methodological approach is helpful and appropriate?
4. **Onto-epistemological reflection**: What are my own assumptions, training, beliefs and experience? How does this affect my approach to the research? What are my biases, preferences and ethical framing and how does this compare to other participants?

Summary

Through an investigation of the various aspects of transdisciplinary practice (previously highlighted in Chapter 4), a series of core principles have emerged with associated pattern sets. In the following chapter (Chapter 6), I synthesise an emergent relational methodology for transdisciplinary practice based on the principles and pattern sets emerging from this chapter and Chapter 3.

Three pattern sets emerge from this chapter. The first of these is the paradox sets which are a tool to engage with tension in a creative and productive way. They are:

- parts and wholes
- stability and chaos
- creativity and rationality
- individuals and society.

The second pattern set is the five doorways to understanding (or lenses on the Lebenswelt (life-world)):

- physical
- social
- ethical
- aesthetic
- sympathetic.

The third pattern set is a typology of reflection and reflexivity:

- practical reflection
- instrumental reflection
- theoretical-conceptual reflection
- onto-epistemological reflection.

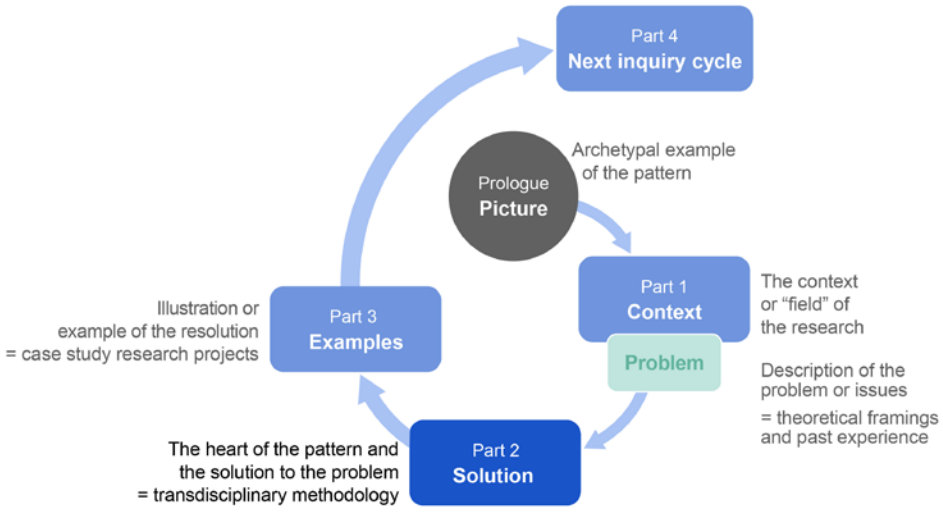
In the following chapter I bring together all four pattern sets and the methodology for transdisciplinarity in five principles.

PART 2

SOLUTION: AN EMERGENT METHODOLOGY

Snapshot

In Part 3, I describe the proposed solution to my thesis questions. This is an emergent methodology for transdisciplinary research practice. In this part, I describe the five principles that have emerged from the theory and the practice (data collection) and the pattern sets through which I apply them. This is the centre or pivot of my thesis, around which the preceding theory chapters and following findings and analysis chapters revolve and inform each other.



CHAPTER 6
A RELATIONAL METHODOLOGY FOR STRONG TRANSDISCIPLINARY INQUIRY AND PRACTICE

The preceding section includes the theoretical underpinnings for my proposed methodology for transdisciplinary practice outlined in this chapter. I describe it as a methodology, in the sense that it is a set of underlying principles, rules and ways of thinking for organising transdisciplinary inquiry and practice. In the following chapters, I apply these five principles to the analysis of the three case study projects firstly to examine the transdisciplinary practice and experience of the researchers, and secondly to refine and test the principles as potential useful tools for application to transdisciplinary research practice more generally.

This chapter sits at the centre of my thesis and is the "kernel" or pivot, with both the theoretical synthesis (three preceding chapters) and the practical experience of the case studies (four following chapters) feeding into it and revolving around it.

Through this, I am looking beyond current conceptions and practice of transdisciplinary research to address some of the underlying challenges, and help to progress practice to the next stage of its development.

The theoretical underpinnings from the previous section include three very broad domains: complexity theory, transdisciplinarity, collective and social learning and reflective practice. A number of important strands have emerged both from the theory and also from the data and field experience of this study.

In talking about the co-evolution of interdisciplinarity and complexity thinking, Klein describes "knowledge as a network or web, with multiple nodes of connection and a dynamic system" (2004a, p. 3). She says that metaphors of unity are being replaced by metaphors of plurality and relationality. On this basis, I am describing the methodology outlined in this thesis as a relational methodology for strong transdisciplinarity. As part of this methodology, I propose that effective transdisciplinary practice requires the application of the following five principles.

Principle number 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity

Principle number 2: Co-production of knowledge across knowledge boundaries or knowledge cultures and worldviews requires an inclusive, shared language for human and social inquiry

Principle number 3: Working constructively with tension is a catalyst and foundation for transformational learning and change

Principle number 4: An iterative or recursive research inquiry process is essential for transformational learning, and for theory and practice to constructively inform each other

Principle number 5: Reflection and reflexivity is essential to enable the researcher to constructively capture transformational knowledge co-production.

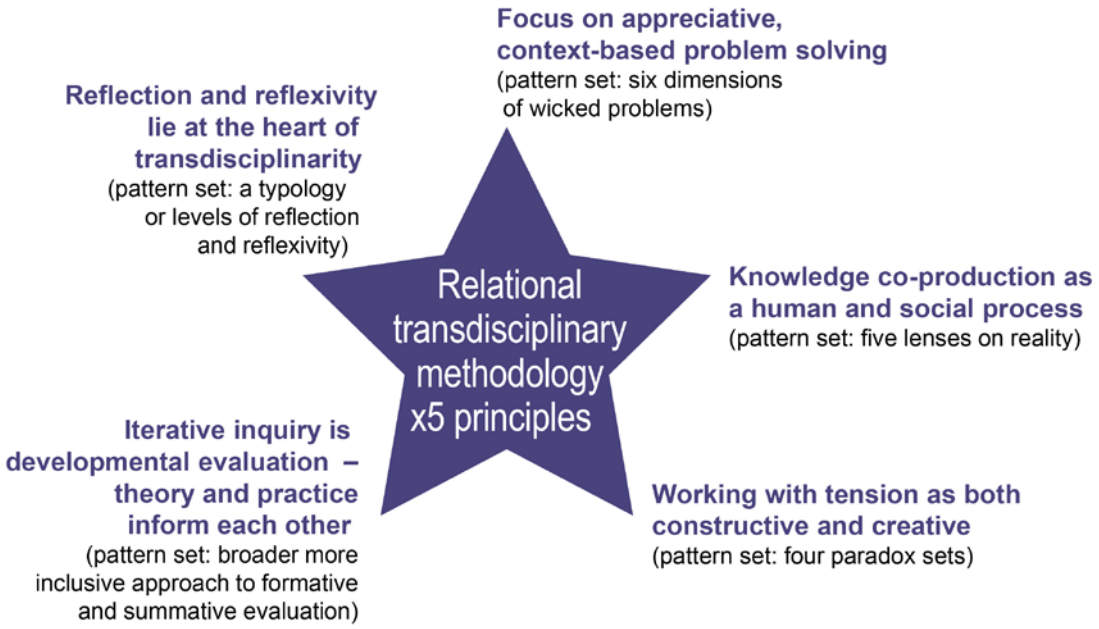


Figure 4: A transdisciplinary methodology in five principles.

For each of the principles outlined in this chapter, I have included (a) the statement of the principle, (b) a brief outline of the theoretical underpinning, the methodological framing and shift in ways of thinking, and (c) a practical tool or "pattern set" to put this

into action. “Formalising and quantifying the notion of pattern and the process of pattern discovery go right to the heart of scientific practice” (Crutchfield, 2003, p. 31). For innovation to occur requires “a break from inadequate model classes, incorrect assumptions and current language” (Crutchfield, 2003, p. 41).

As previously described, I use the term “pattern” to denote an element that repeats in a predictable manner, or which is in some shape or form regular. A “pattern set” is a group of these patterns which complement each other and can be used as a tool to achieve sense-making in complex systems, and where multiple world-views and ways of knowing come together, given that in complexity research, “contradictory mental models need to co-exist” (Ramalingam, 2013, p. 234). The specific pattern sets I have used in this thesis should not be considered as part of the methodology (or for that matter the conceptual framework) but are chosen as being appropriate to the context. Other sets may be chosen in other contexts. I draw on the five pattern sets identified and outlined in Chapters 3 and 5.

Principle number 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity

The context for a transdisciplinary research study, and the problem definition that fits within this is challenging. In a self-organising complex system (see Chapter 3), there is no equilibrium but a constant shifting of state. Most of the social problems we are dealing with fall into this realm, where the focus is on uncertainty, dynamism and diversity of complex ecological, economic and social processes, and where social and physical systems are inextricably intertwined. In such a situation, the problem is likely to be a wicked one, and definitions highly fluid.

Nailing down a problem statement in such a context is fraught with difficulty, with approaches often falling between oversimplification, or excessive detail and complication. Identifying, defining and articulating research problems in complex, real-world, wicked problems means attempting to bring together different, and in some cases incompatible, components and conceptions of the problem.

In addition, our conceptualisation of a problem is limited by our own knowledge, experience, assumptions and preferences. And bringing together different worldviews is

not enough. Our tendency is to try to reach consensus – to take the majority or agreed view – which serves to limit our understanding of the problem and its context.

The first principle is to take a collective, inclusive approach to appreciative context-based problem framing, incorporating the following two elements.

1. It is an appreciative approach from two perspectives. Firstly, that the research focuses on possibilities and potential rather than just deficiencies and problems, and secondly, taking a non-judgmental and inclusive approach to the varied conceptions of context and problem from across the spectrum of team members and stakeholders for a more collective approach.
2. A focus on context without narrowing and simplification is important from two perspectives. The first is to ensure a holistic view of the problem arena, and the second is to avoid limiting the possibilities for solutions, or focusing the problem statement on a preconceived solution option. In particular, given that such complex, wicked problems have by definition no final or single solution, this allows an ongoing focus on the context and its changes.

The pattern set for this principle is the six dimensions of wicked problems adapted from Ashhurst (2014), which I outline in Chapter 3. I use this pattern set to explore a creative way to investigate and document wicked problems in the framing and design of research, as well as to provide a tool for dialogue and problem exploration for future projects. I also use this framework for two additional purposes. Firstly, this situates the researchers in the research context and to open up the problem framing, and secondly, it is a means to include a broader range of project stakeholders in the process of understanding and unpacking the problem to be addressed.

For the six dimensions of this pattern set, I pose a series of indicative questions.

1. **Diversity**: Who are the various stakeholders/participants (researchers and non-researchers) and what are their viewpoints/expertise? What is the range of expertise and experience that can (and should) be included in this research inquiry? How socially complex is the context? How diverse is the context of the problem, and how can we deal with this? What sociological and cultural and other differences (e.g. gender, ethnicity, education etc.) do we need to

understand or take into account?

2. **Intractability:** How flexible (or not) are the various participants and stakeholders in terms of embracing different approaches and worldviews? How aware are they of different worldviews? How adaptable and flexible can the project and its participants be? What are likely to be some of the keys sources of unpredictability and what scope is there to respond to this? How (in)flexible are organisational or socio-political structures?
3. **Complexity:** What are the components of the system (including human and non-human)? What are the key sources of complexity? What is the extent of the system, what are the component parts, and what comprises the whole? What are the important relationships in this context? Where are the synergies? What is the level of "messiness"? How much detail should we engage in?
4. **Ambiguity:** What contradictions in meaning and perspective are emerging? What different interpretations are possible? Which aspects of the context and problem are uncertain or unpredictable? How uncertain is the data? What possible courses of action are possible?
5. **Instability**: How dynamic is the context and the problem? What level and rate of change is happening around the problem? What changes in thinking, situation, constraints etc. are likely? What are some of the drivers of instability? How can we plan for this? How often do we need to review our problem definition and approach?
6. **Confounding factors:** What factors are likely to confound or limit actions or alternatives? What might be the limitations in adaptive capacity or resilience? What are the constraints that will hold us back, or limit solutions? Are there conflicting outcomes, goals or actions?

These are not discrete elements nor are they a classification system. Instead, they provide a way to bring together or group elements of the context and problem situation as a set of provisionally universal patterns.

It is important to note that this particular framework is not the only way in which this principle can be applied to transdisciplinary practice. The point is to create a heuristic that serves as a dialogical tool to enable the participants themselves to tease out the

different elements of the problem in a way that is inclusive of worldviews and perspectives. In addition, the framework is designed to provoke reflexivity in problem framing and problem solving by placing the researcher firmly in the researched context.

Principle number 2: Co-production of knowledge across the boundaries of knowledge cultures and worldviews requires an inclusive, shared language for human and social inquiry

Once the context and the problem have been explored, research teams need a way to bring together their own and non-researcher participants' experience, knowledge and ideas towards the inquiry process – to propose and seek the answers to research questions.

This bringing together of experience, knowledge and ideas often amounts to vastly different world views which may be difficult not just to reconcile, but to communicate. Every discipline and area of expertise has its own language and way of communicating among its members, as well as its own set of questions. For a truly synergistic approach in transdisciplinary research there need to be connections, bridges, continuity and a shared language to allow for communication across the boundaries of knowledge cultures and world-views. Having a series of parallel inquiry processes based around disciplinary specialisation does not achieve this.

In addition, there is a need to invoke "strong transdisciplinary" practices as described by Max-Neef (2005) through not only spanning different realities, but also through what he describes as different levels of reality and systems. Nicolescu's (2014) idea of a shared methodology for transdisciplinarity is a key part of this. Rather than an "anything goes" methodological approach, there needs to be agreement at the higher levels (epistemological and methodological) about how to approach and reconcile the variety of world-views.

One of the challenges here is to not privilege (or marginalise) a particular discipline or worldview. In most of the interdisciplinary research projects I have experienced, there has been a "dominant" or "primary" discipline, to which the others in the team are subsidiary or secondary. As most of us are trained in a particular discipline or combination of disciplines, the challenge is to come up with an inquiry framework or a

way of asking research questions which is inclusive of all the ways of thinking and expertise, and which stops key lines of inquiry and evidence from "slipping through the cracks" or being overlooked. This goes beyond current co-production and participatory action research approaches, and aims to create synergies to develop a richer knowledge.

The second principle, that knowledge production is a human and social process, reflects the parallel ideas of collective, social and evolutionary learning as a foundation (as described in Chapter 4). My starting point is the five doorways to human understanding or "lenses" for understanding the world which I outline in Chapter 5.

The five doorways or lenses for human understanding, which form the universal provisional pattern set for this principle are physical, social, ethical, aesthetic and sympathetic. These five provide a series of lenses to view, or doorways to enter, the inquiry to generate the research questions and identify evidence. These five ways of knowing are outlined in more detail in Chapter 5, but briefly summarised here.

> **1. Physical:** What are the material and physical elements of the system? What do we need to measure? What influence do the physical components have on the system? This lens is to do with the material world and the evidence of the senses and generated through measurement and observation, and is about that which is tangible.
>
> **2. Social:** What are the images, metaphors, narratives, myths, symbols, behaviours and beliefs of the community and the individuals? What are the social practices and structures, and how are these changing (or how might they be changed)? What are the discourses, conventions, institutions and practices? This lens generates questions and understandings through the lived experience of the community and individuals, and includes language, images, metaphors, narratives, myths, symbols, behaviours and beliefs. This lens can be confusing as there is a tendency to conflate the social and physical (e.g. mistaking money for a "real" physical thing – coins or notes are physical things, money is a socially constructed concept).
>
> **3. Ethical:** What is the range of ideals, values, principles, aims and standards of good and bad of the various worldviews represented in the project? What are the

preferences and ethical priorities of the various stakeholders or participants? And what are the implications from this for their preferred outcomes? What are the underlying rules and standards of the various social networks and systems? And how might this influence choices and decision-making? How should this influence the direction and approaches of the research?

4. Aesthetic: What are the aesthetic principles and standards of the participants? How will the proposed pathways and solutions in this research affect the participants in terms of wellbeing, happiness, joy, hope, despair etc.? What are the different perspectives on designs, visions, and concepts of beauty and ugliness which inform the research? Through this lens come the evocation of feelings such as well-being, happiness, joy, hope, sadness and despair – all essential human experiences.

5. Sympathetic: What are the connections and relationships between people and things? Which relationships and connections will be most important in this research? How does this influence the dynamics of the system within which the research is being conducted? This includes concepts such as trust, relationships, sense of others, leadership, conflict, friendship etc.

Using these five doorways or lenses is a means to generate research questions that reflect collective and human inquiry, rather than the narrower range of questions and inquiry that are possible through a disciplinary lens. It is important to emphasise here that this does not replace or make redundant the idea of disciplines or disciplinary training, instead it provides a way to bring together disciplinary knowledge and questions in a more synergistic way.

This allows for knowing as well as understanding (as outlined by Max-Neef, 2005), where knowing is cognitive, and understanding is more about experience, and relates to the concept of "*Lebenswelt*". Not only do they transcend disciplines, these lenses or doorways are ways to explore the questions in a more comprehensive way. In other words, it is a way to bring together, rather than divide and exclude as disciplinary thinking does. I propose this as a way in which the world can be viewed in a more systemic and holistic way.

These five doorways to human understanding also need to be thought of from the perspective of what Max-Neef (2005) describes as different levels of reality where different rules apply. There are many conceptions of these different levels, including different systems levels (e.g. farm household, paddy field, national, ecological) and levels of reality (e.g. practical, abstract, theoretical etc.). These five doorways must always be considered in relation to reflection and reflexivity (see principle number 5).

Principle number 3: Working constructively with tension is a catalyst and foundation for transformational learning and change

In posing questions according to the five doorways or lenses for understanding (see principle number 2) dualisms and dichotomies (and seeming paradoxes) surface and create tension in the process of posing questions as part of the research investigation. This includes the process of bringing together widely different worldviews, to deal with wicked problems. Research teams not only need constructive and creative ways to deal with these tensions, but also to use these tensions as a source of constructive dialogue and creativity as a part of collective inquiry and learning.

As outlined in Chapter 5, Enlightenment thinking has tended to promote binary thinking – i.e. "If not A, then must be B" rather than allowing that A and B can exist at the same time, and introducing a third state of being, C. This is also described by Max-Neef as the "included middle". This approach is a direct challenge to linear and binary thinking and logic of the Enlightenment, going back to the Aristotelian tradition (Max-Neef, 2005, p. 10). I take this a step further, to propose that rather than an "included middle" (which infers an existing state of set of options), the resolution is a set of creative, new possibilities, rules and understandings, which is the essence of transformational thinking.

There is an additional perspective on the sources of tension in transdisciplinary practice, and that is the pattern conflict, or the dissonance that arises from differences in worldviews. These are inevitable, and can be seen as a source of new solutions and rules rather than stumbling blocks.

Embracing the tension between dichotomies, dualisms and pattern conflicts is important for three reasons. Firstly, the tension and potential dissonance is a catalyst for new

thinking and novel solutions (and is the precursor for what Bateson calls deutero-learning or learning to learn where the learning being is subjected to a situation where it cannot learn from existing patterns and behaviours but must invent new behaviours).

Secondly, it creates a space for critical dialogue between the different world views present and allows movement between system levels and levels of reality (as outlined by Max-Neef). Thirdly, it catalyses a departure from binary thinking, which limits our ability to find novel solutions and to deal with highly complex situations and problems.

In addition to fostering a more inclusive and "human" inquiry process, I address the issue of what Bastardas-Boada calls "excessive separation" (2014) and Ansell (2011) and other pragmatists call dualism. This is the bringing together of seeming opposites in a dynamic system – things that seem to be incompatible opposites, such as parts and wholes, individuals and society, stability and chaos, and rationality and creativity (Brown & Harris, 2014)

While there is any number of different combinations of seeming opposites, I have used these four as the pattern set to analyse and interpret the findings from the case studies. For each of the pattern set (as for all the pattern sets) I pose a series of questions.

1. **Parts and wholes**: What conception(s) of the "whole" or system will be most useful here? And are there nested systems (systems within systems) that can be useful in this inquiry? What attributes and behaviours can be attributed to these wholes? And what are the parts within these wholes? And what wholes do the parts represent? What are the relationships between the parts? And how are the parts different and distinct from the whole? What are the patterns that connect the parts? How can the tension between the two be a source of learning and new thinking?

2. **Individuals and society**: What are the various groupings and societies that individuals are part of? How is their reality constructed? How does the diversity and heterogeneity of individuals play out in the various "society" groupings? What are these groupings (e.g. schools, communities, administrative boundaries, national groupings, professional and ideological etc.)? What does this tell us about how to deal with various social "scales"? How can the tension between the

two be a source of learning and new thinking? While we act as individuals, at the same time, our experience and our learning is socially constructed.

3. **Stability and chaos**: What elements in the system are stable or organised or ordered? And where are the sources of dynamic change and instability? What is the tension between ordering patterns and disordering dynamics? How do we engage with this for learning and positive change, what are the possibilities for deutero-learning? How can the tension between order and chaos be a source of learning and new thinking?

4. **Creativity and rationality**: The juxtaposition of creativity and rationality broadly underpins the learning cycle, as described by Kolb and others. How can we bring together concrete experience, reflection and intuition, abstract rationality and active experimentation for constructive and innovative learning? What are the sources of gestalt versus logical thinking, subjective versus objective, intuitive versus stepwise analysis etc., and how can we creatively engage with this?

Bringing these seeming opposites together in tension is a way to create a catalyst and foundation for transformational learning and change. And not just incremental learning, but triple-loop and/or deutero-learning. These seeming opposites need to be “outed” as they restrict or constrain thinking and allow a move away from an “either/or” framing.

This allows for a richer and broader field of inquiry. This inevitably results in tension – as it implies questioning and opening up of held beliefs and world-views. Ansell (2011), and many of the Pragmatists he quotes, regard recursiveness as the key to dealing with these dualisms or dichotomies which are so prevalent in our post-modern thinking. For example, Ansell gives the example of Bateson’s idea of a recursive model focused on understanding how parts might comprise a whole, as well as how the whole “reentered” the parts, which he called a form of causal looping (Ansell, 2011, p. 106).

Principle number 4: An iterative or recursive research inquiry process is essential for transformational learning, and for theory and practice to constructively inform each other

To engage constructively and creatively with the tensions created by the dualisms and seeming paradoxes in wicked problems, an iterative approach is required as all solutions are partial and ongoing, and require progressive learning as well as cycling between theory and practice. This reflects Ansell's concept of evolutionary learning, where there is continuous and recursive learning and growth among all the stakeholders in the project, both individually and collectively. This process requires challenging existing assumptions, values and knowledge and requires deliberation in response to seeming dissonance of two seemingly incompatible opposites being brought together in creative tension. It also rules out a linear approach to inquiry – and questions the value of log frames and other linear or predictive approaches to inquiry.

This iterative approach is adopted in this thesis – a series of loops and recursions working between the seemingly separate worlds of theory synthesis and data analysis to develop this set of practical yet theoretically-based principles for transdisciplinary research practice.

I emphasise that this recursiveness or iterative approach must go beyond a linear conception of a coil or spring-like looping in a single direction. Instead, it becomes much more multidirectional, as it has to include the widely varying worldviews of participants, fluctuations and instability in the context and problem focus, and a more multidirectional process of inquiry. While the overall project direction may remain reasonably consistent, the process or path the inquiry follows is allowed greater freedom to adapt and respond to the context.

As outlined in Chapter 5, recursiveness is essential for the Pragmatist idea of evolutionary learning, and should be closely and productively coupled with developmental evaluation. Developmental evaluation, as defined by Patton, is a combination of both formative and summative evaluation, that is, focusing on improving and adapting the inquiry as well as making judgments about the project at the same time (2011, p. 1–7).

In the case of transdisciplinary research it is not helpful to rely solely on disciplinary peer review and expert opinion. Instead a broader, more inclusive and much less linear process is required. Patton also highlights the importance of the interpretation of data – even about how the quality or reliability of data is assessed. He suggests that the almost obsessive focus on the quality and accuracy of evaluation data is of little value unless the researchers have the capacity to think, interpret and evaluate critically and appropriately, and come to reasonable and supportable conclusions (2011, p. 13). This also applies to the broader process of data interpretation and findings (though I think the two are closely related particularly in terms of the iterative approach discussed above). A key requirement for achieving this is reflection and reflexivity.

Principle number 5: Reflection and reflexivity is essential to enable the researcher to constructively capture transformational knowledge co-production

The previous four principles are useful only when combined with individual and collective reflection and reflexivity. Without reflection, learning is limited. Brown and Harris describe both introspection (knowing yourself) and reflection (reflecting on the interpretation of the observed and experienced researched context and problem both individually and socially). Firstly, to reflect on the answers and to synthesise, and exercise "craftwork", and secondly, to reflect on the methods, approaches and processes used in the research to gain valuable insights and lessons for further research as well as the more immediate outcomes of the project.

While reflection on the data and details of research is fairly standard research practice, the deeper reflection on the self is from not just a professional or disciplinary perspective but from the perspective of one's personal knowledge, experience, assumptions and preferences. Reflection also includes various levels or typologies, ranging from reflecting on the project practice and results, right through to onto-epistemological reflection (Salas-Zapata et al., 2013). Without the process of reflection, the transformational knowledge co-produced in transdisciplinary research cannot be captured.

The pattern set or analytical tool I have adopted for principle number 5 is outlined in Chapter 5. It is an adaptation of the Salas-Zapata et al. typology of reflection, designed to look more closely at the approaches, levels and effectiveness of reflection in the

context of ongoing and iterative research monitoring, evaluation and design. I have modified the original typology to reflect the perspectives from the case study projects and to reflect the conceptions of Fook and Gardner (2007), Brown and Harris (2014) and Popa et al. (2014).

The four levels of reflection in this typology, and some characteristic questions asked of oneself and the collective group are included in Figure 5 below.

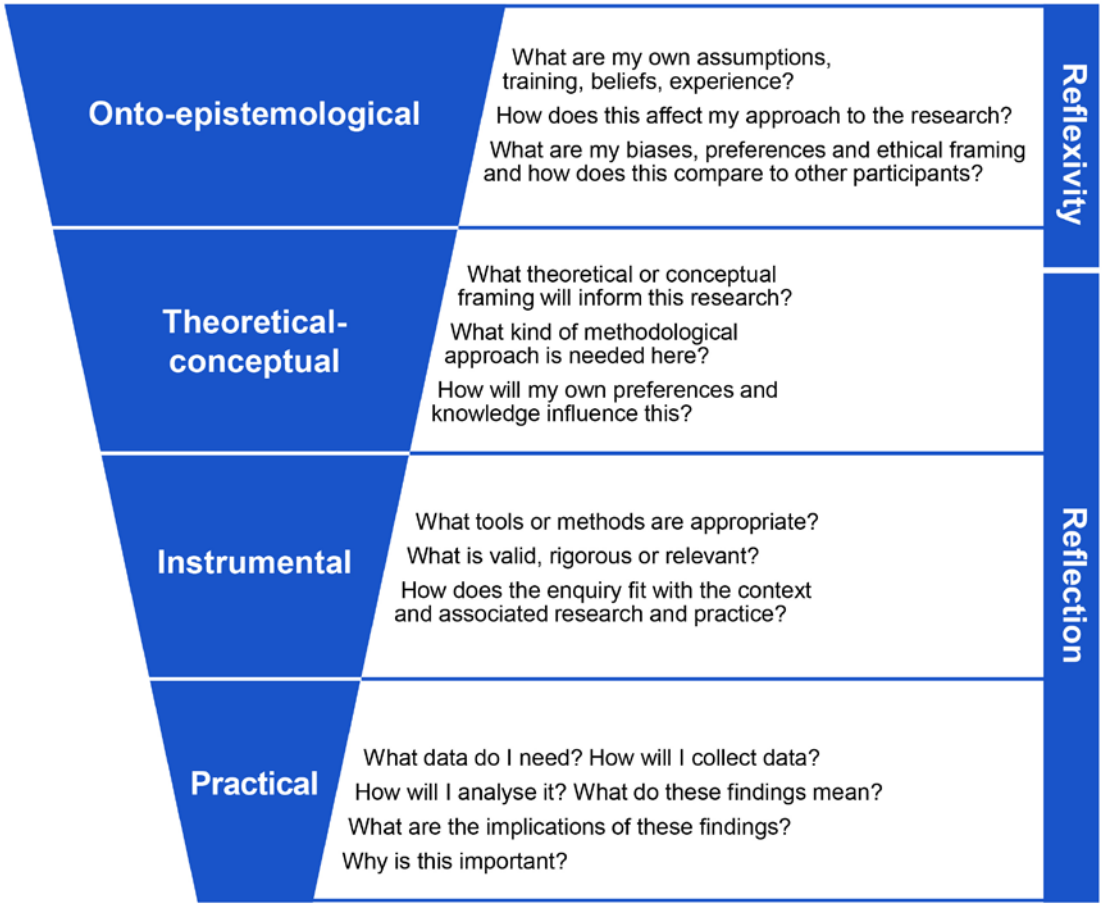


Figure 5: A hierarchy or typology for reflection and reflexivity

A key aspect of reflection is about the dynamics of power. Power as a dynamic and relational concept is a cross-cutting theme weaving through all of these principles. Without reflection, and in particular self-reflection, it is goes unremarked and in many cases unnoticed (particularly for those who are more powerful). Personal power is social, situational, psychological and spiritual and generally has a major influence on rural research for development and its outcomes (Wolfson, in press; Foucault, 1991;

Freire, 2006).

Testing and applying the principles

In Part 4, I test these five principles against the three case studies using the tools described.

PART 3

ILLUSTRATION: TRANSDISCIPLINARY METHODOLOGY APPLIED TO THREE CASE STUDY PROJECTS

Snapshot

The following section contains the findings and analysis, according to the five principles for transdisciplinary research practice and associated pattern sets, as outlined in the previous section.

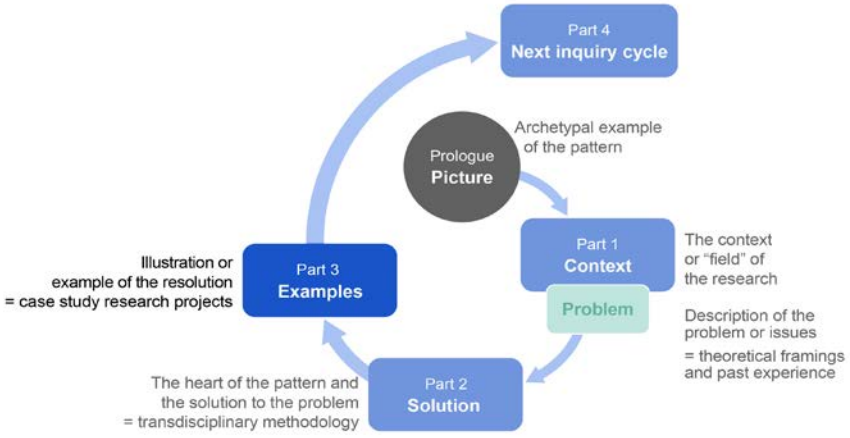
Chapter 7 provides a narrative for each of the three research projects, and details my learnings and insights and the way in which they each informed (and were informed by) the parallel theory exploration and synthesis. Chapters 8 to11 are focused on Case study 3, and provide a more detailed analysis against the five principles using the provisional or example tools I outlined in Chapter 6.

Note: Naming convention for findings:

Case study 1 = CS1 (researcher respondents denoted by CS1A, CS1B, etc.)

Case study 2 = CS2 (researcher respondents denoted by CS2A, CS2B, etc.)

Case study 3 = CS3 (researcher respondents denoted by CS3A, CS3B, etc.)



CHAPTER 7
THE CASE STUDIES' NARRATIVES

The empirical research in this thesis is based on a study of three case study research for rural development projects, and the transdisciplinary researchers and other participants in these project teams. Based on the adaptive theory methodology (outlined in Chapter 2), Case Study 1 (seasonal climate forecasting for farming to enhance food security) is the pilot study, with Case Study 2 (family poultry production and crop integration for food security and nutrition) providing the canvas for the initial development and testing of the ideas and theory. The third case study (multi-scale climate adaptation for rice-based farming communities) is used to test the emergent theory and is studied in greatest depth, culminating in a detailed analysis using the theory that forms the basis for the transdisciplinary methodology.

This chapter outlines a summary of findings from each case study, largely in the form of a narrative. It also outlines the data collection for each project.

Case Study 1: Improving seasonal climate forecasting to enhance food security in the Indian Ocean Rim (India and Sri Lanka)

The first case study, which has been a pilot study for my thesis fieldwork (as part of the adaptive, iterative approach discussed earlier in Chapter 2), focused on enhancing seasonal climate forecasting to improve livelihoods for farmers in India and Sri Lanka. This case study helped to inform my research approach and data collection for subsequent case studies, through my observations and interactions with the project, and the kind of questions that this raised for me about transdisciplinarity and its practice.

It was particularly influential in highlighting the role of problem framing, which gave rise to Principle 1 (A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity), as well as highlighting the importance of co-production of knowledge across different ways of knowing and world views, which helped to frame Principle number 2 (Co-production of knowledge across the boundaries of knowledge cultures and world views requires an inclusive shared language for human and social inquiry).

To a lesser extent, this project raised questions for me about paradox and tension, and how this might play out in different projects, which eventually led to the emergence of Principle 3 (Working constructively with tension is a catalyst and foundation for transformational learning and change). In addition, the focus on reflection in one of the work packages formed the idea of Principle 5 (Reflection and reflexivity is essential to enable the researcher to constructively capture transformational knowledge co-production).

In this section, I outline key findings from Case Study 1, and conclude with a summary of insights and learnings in relation to each of the four principles described above.

Involvement and data collection

My involvement in this project spanned the scoping phase of the project, the development of the full project plan, and the early stages of implementation. My interaction with the project ended quite early in the implementation phase, soon after the baseline study fieldwork was begun. As a result, my data collection and findings cover only the early stages, and I do not comment on (nor do I have access to) the final outputs and outcomes of the project.

During the course of my interaction in this project, I interviewed 19 participants, with five of them interviewed either two or three times. The interviewees included members of the Australian project team, but the majority of interviews were with the Sri Lankan researchers and participants, including the university team and the International Non-Government Organisation (INGO) involved in the project. My role in this project was as an observer, and informal member of the project team.

I participated in four in-country field visits – one to India in the scoping study, and three to Sri Lanka – the scoping study trip, an extended visit after project inception, and a subsequent short visit to attend a training workshop which a number of the project researchers attended. Each field trip included visits to the farming villages that were participating in the research. I also attended key project meetings and workshops, including the scoping workshop, inception workshop, and project team meetings in Australia and Sri Lanka. I kept an extensive diary of my participation and observations as well as key documents associated with the project.

Scoping study

I became involved at the commencement of the scoping study, after the concept note was circulated to the team. The project was funded through the Australian Government, and from the donor perspective the project was primarily aimed at participation in regional Indian Ocean Rim scientific initiatives as part of diplomacy in the region. Improving seasonal climate forecasting at the farming community level, and management of climate risk was, however, a common goal for the countries involved in the research. The donor had asked the project leader to put together a project with the above objectives in mind, and had provided him with a set budget from the outset. So activities in the project had to be tailored to fit the amount of funding allocated.

The objective of the project was "… to investigate the use of seasonal climate forecasts to enhance food security in South Asia by reducing agricultural production risks associated with climate variability and climate change, and by developing a blueprint for the use of improved seasonal climate information across case study regions in the Indian Ocean Rim".

The expected outcomes stated in the project plan were:

1. Improved seasonal climate forecasts that incorporate climate changes available for stakeholder-defined variables in the case study regions.
2. Case study decision makers have enhanced access to, understanding of, and capacity to use the improved seasonal climate-forecasting products for the purpose of exploring improved agricultural decision making.
3. Enhanced links and scientific exchanges between relevant Indian and Australian institutions and across the Indian Ocean region through a workshop involving IOR-ARC member countries.
4. Methods and approaches transferable to other Indian Ocean Rim countries such as those in Africa to enhance current levels of climate risk management.

Seasonal climate forecasts in this project were defined as intra-seasonal to seasonal forecasts across month to multi-month timeframes, as opposed to 3 to 10 day weather forecasts. In particular, these medium term forecasts were targeted as a first priority

towards the specific needs of smallholder farmers in decision making and incremental adaptation to variability in climate. The project had a multi-scale focus from engagement at the Indian Ocean Rim countries, right down to the farm household level.

The project leader had assembled a group of scientists with whom he had worked previously to develop the scoping study for the project and to firm up plans for the scoping study activities. The project team included Australian, Indian and Sri Lankan participants, and a very wide breadth of disciplinary expertise. The team included climate scientists, statistical modellers, agricultural systems researchers, livestock scientists, and social scientists (anthropology, psychology and economics), as well as ecologists and rural development specialists, many of whom were non-researchers. A broad range of others participated at various stages, including local district extension staff and government staff with varying expertise. The Sri Lankans included university researchers, government officials and an INGO that had worked closely with farmers on a number of projects.

The first scoping visit was to India, and was centred on visits to, and discussions with, key partners culminating in a scoping workshop. Although no farm or village visits had been planned, I and one other researcher were invited to go on a field visit to one of the communities that the INGO had been working with for some time. We travelled down to the provincial area by overnight train arriving in the early morning to be greeted at the INGO project office with morning tea and a meeting with the local staff who have established a strong local presence and are working with the local community on a range of initiatives including weather recording (through a locally maintained weather station), short-term weather forecasts via a subscription mobile phone message service, supporting farmer groups, and a village knowledge centre.

We met with a farmer group and were in time to hear the daily broadcast weather report that came through on the group leader's mobile phone. They talked to us about their own weather observations and measuring. They told us that observation of wind direction, speed and consistency were very important to predicting the amount of rainfall at various times of the year. They also agreed that the weather patterns that they observed had changed in recent years, and that they were not as confident about predicting seasonal conditions as they had been in the past. While this is anecdotal

information from one small group of farmers, it highlights that these farmers pay close attention to weather conditions and discuss them constantly.

Our next stop was the local knowledge centre. Here we met a group of women who were responsible for putting together the weather forecast (from the Indian Meteorology Department in New Delhi) that would then be broadcast via mobile phone message, and by posting a paper copy in each village centre. They showed us the village social map, which was rich in information on livelihoods for each household and is used to facilitate access for householders to appropriate government services within the village. In addition, they were offering literacy courses for the local women.

We arrived back in Chennai in time to meet up with the climate science team who had been visiting the Indian Meteorological Department and other key stakeholders to negotiate the sharing of climate data for the modelling.

We all attended the scoping workshop in Chennai, with participants from Australia, India and Sri Lanka. This workshop was focused on developing and agreeing to the outline for a project plan between the various participants (which included universities and INGOs from both India and Sri Lanka, as well as the Australian team). A considerable amount of time was spent mapping out and looking at the cropping cycle for farmers in each country, to determine where a seasonal climate forecast might be of most use, such as determining planting or harvesting times, crops and varieties to plant, post-harvest storage and so on. In addition to the extensive work we saw in the province with the Indian INGO, most of the researchers had already worked on a variety of projects including looking at forecasts for farmers, climate advisories, and adaptation to climate variability. Case Study 3 (focused on climate adaptation in farming systems) was already operating in India and many of the same partners were engaged in both projects.

The workshop highlighted some fundamental differences in focus and outlook for the Indian and Sri Lankan counterparts regarding farming systems. The Indian scientists were opposed to including livestock in the farming system mix, whereas for the Sri Lankans, including livestock was essential. A heated argument ensued. This is despite the fact that livestock play an important role in farming systems in both countries, though there appeared to be an interesting paradox between the nature of the role of

livestock and the cultural and religious attitudes in each country. For example, two of the Sri Lankan researchers explained to me that Sri Lanka is a Buddhist country where talking about meat production and consumption is not culturally or religiously correct, though meat is readily available and locally produced, and there is considerable prestige associated with having a large herd of domestic livestock (particularly cattle).

The second scoping trip was to Sri Lanka, and included visits to the local communities which were to be included in the study. This selection served a multiple purpose. Not only were these communities (villages) the case studies for the project, they also provided the INGO with access to additional communities for their more general rural development work (though they would have preferred to work in the predominantly Tamil areas on the north and east where their work is more generally focused).

The villagers in general had a lot of contribute on the subject of seasonal conditions. They spoke about the sort of seasonal forecast indicators they relied on, which included the number of eggs laid by the crow (more eggs meant a better season), where the weaving bird situates her nest (a higher nest may indicate flooding), and various aspects of animal and plant behaviour. One village leader, in particular, had kept detailed records over a number of years of rainfall in the village area, and our visit and questions stimulated much discussion and debate about seasonal conditions and the impact on their livelihoods.

In addition, several of the local participants (in both India and Sri Lanka) spoke about multiple relevant and associated projects in both Sri Lanka and India that they felt this project could build on, and create synergies with. The project plan reflects the synergies with other climate-based projects, but not with farmer livelihood and climate adaptation projects that may have potentially provided context and background.

Project plan development and implementation

The project plan defined five “work packages” including analysis of existing climate risk management, information networks and dissemination systems; development of improved seasonal forecast products/systems; decision analysis and testing of seasonal climate forecasts for agricultural decision making; capacity building and knowledge sharing; and monitoring and evaluation. The various research activities within the work

packages operated quite independently of each other with regular "integration sessions" with the work package team leaders.

During the early stages of implementation, I spent two months in Sri Lanka, travelling between Colombo, Kandy and the three field sites in the dry zone in the east, interacting with the local project team. This included regular and frequent visits to the university and INGO offices, and a field trip to one of the case study districts for the pilot of the baseline survey. The baseline survey was an omnibus – a combination of questions compiled from suggestions from the various researchers to meet the needs of a number of the work packages. In addition, a social network analysis was also planned, which required quite detailed and comprehensive data. Finalising the baseline survey and gaining agreement from all the contributors was a challenging process.

I observed the development of the baseline survey, which was coordinated by CS1I, a university academic. CS1I told me that the survey was very important. He emphasised the importance of interviewing the people at the village/farming household level, "*because they are the people who will really suffer*" the consequences of climate variability and climate extremes. He said, "*… if you take the climate change dialogue, it is at the top level. The people who really suffer are not taken into the discussions*."

CS1I was excited about this project because he saw it as an opportunity to collect and learn from local and traditional knowledge, "*and then tally up the experience (local knowledge) with the (scientific) data and how accurate they are thinking, and what kind of lessons we can pass for the future*."

Many of the Sri Lankan project team members talked to me about this, particularly in the context of their work with farmers. Almost all this group of informants talked to me in interviews about understanding farmer perspectives and taking these into account. Two of the informants in particular talked a great deal about local or traditional farmer knowledge and the value of this.

CS1D said: "*So they do different things in different seasons, but there isn't I guess a shared language or a shared knowledge about it. It's more about what different people do.*"

I asked CS1L what he had learned from the farmers he worked with. He said. "*They*

have their own wisdom. When we talk about adaptation to the climate change, we talk many things. But they have their own way of managing things. For example, in one year … they told us they had two varieties, we have distributed our risk. One is tolerant to high rainfall, one is tolerant to dry. They tell us the reason why the variety failed in one test and the other didn't. They explained the land configuration, the soil etc. We had been advocating, but they had not been following. But now they are telling us in a different way, theirs is a very good kind of adaptation."

A number of the Sri Lankan scientists had made detailed studies of traditional and local knowledge in this as well as long-term agricultural and water management approaches and techniques. Over the last 2000 years, Sri Lanka has developed a highly sophisticated hydraulic agriculture system of "tanks". These are both large dams (providing irrigation across a number of communities), as well as small community dams interspersed down a series of long narrow valleys, which are maintained by the local community, and the water shared out for irrigation. This highly adapted system has developed in response to annual rainfall variability, the uneven distribution of rainfall across the year and the unique topography of the valleys. Therefore, water use and distribution, and cropping and management decisions have traditionally been made communally within the local tank community (Panabokke, Sakthivadival & Weerasinghe, 2002; Brohier, 2006). This would indicate that individual decision-making might be less important than collective decisions and actions within a particular group.

CS1S also talked about traditional farmer knowledge about climate and how it was used for forecasting. He talked about another project he was involved in where they were incorporating farmer observations and records, but he felt that, while the traditional and local knowledge had significant value, he was not sure how much it could be accommodated in this project.

I was present as an observer on the day in which the baseline survey questionnaire was finalised, and the enumerators trained. The various researchers (from Work Package One [2] including the two Australians) were present as was the INGO which was

[2] Five work packages were outlined in the project plan, each of which operated semi-independently of each other.

implementing the survey in partnership with the university. Also present were the enumerators – generally extension or other local staff selected from each of the three target districts.

The first point of discussion was the length of, and level of detail in, the survey. The INGO and enumerators were concerned about how much time it would take to run through the survey with each household. The general view of the field staff was that it was too long. Added to this, the Australian team (which had recently flown in from Australia) had that morning produced the additional segment for the survey for the proposed social network analysis that included detailed questions for a quantitative analysis of who farmers interact with, who they receive information from, and the nature of that information.

CS1S explained the purpose of the both parts of the survey to me: "*The baseline survey and the social network analysis, which are the key parts of Work Package One, deal with understanding who our key, at a farm level, plus at a slightly higher stakeholder level (the District and the State level). What this brings out in a very simplistic way is: who is our target audience, what are their decisions and where does our climate science come in. … So what that informs back to the climate science is this is what sort of decisions farmers make, at the start of the season what crop to have, when to harvest, those sort of things and these are the climate variables that might be useful. … So that's the list that comes out from the survey, some understanding of the context in which we are working, and the people we are working with*."

There was a great deal riding on the results of this one survey. It was the key interaction with the farming households that was designed to provide the information needed to tailor the seasonal climate forecasts to the farmers' needs and to develop the delivery mechanism.

The aim of the project was to produce a "useful" forecast for farmers and their communities. One of the researchers (CS1S) questioned the assumption that a seasonal climate forecast would be of benefit to farmers, suggesting that there was potential for climate forecasting to become "advocacy research" saying, "*We sort of say 'seasonal climate forecasts are valuable and we'll show you how valuable they are' without really being open to the question that they may be of limited value*."

One of the researchers, CS1S clearly outlined the issue as follows, *"… it could be a good seasonal forecast, but if your infrastructure is not geared up – if you don't have the right seeds, the right fertiliser, the right storage, you don't have the right mechanisms – then climate [forecasts] can only provide that much more information, it doesn't solve the other set of things. We need to be cognisant that life is more complex than climate! … Some forecasts have no value – you just plant the seeds and it rains*."

Another researcher, CS1A reinforced this, saying that often the actual value of a forecast falls well short of the potential value. He added that without understanding farmer decision-making, perspectives and needs, it was difficult to understand what a "useful" forecast might look like.

CS1F questioned the value of the forecasts as the farmers have many other issues to contend with which a climate forecast may not help. He gave the example of one of the study villages that has an ongoing problem with elephant incursion. He said that one of the larger elephant reserves bordered on the village, and as elephant numbers increased and available land for their habitat decreased, elephants were more frequently coming into the village looking for food, destroying crops and houses and killing people.

Even where farmers prioritized forecasts, CS1S went on to point out that climate forecasts are difficult to "translate" into a language that farmers will understand, given the knowledge and expertise differences between farmers and climate modellers. This challenge is much broader than this project. For example, Hulme talks about the desire to create "universal language" around global issues such as climate change and the risks of being "insensitive to the peculiarities of place and context" (2010, p. 559). Hulme uses the example of mean global temperature that has been reified to represent an indicator or flat measure of climate change, which does not speak to the vast diversity and complexity of the realities of climate change across the globe (2010, p. 562). Similarly, a seasonal climate forecast is necessarily a summary based on one kind of expertise being extended to another expertise or world-view with different needs, expectations and experience of weather (given that we experience climate as weather).

The climate scientists I interviewed told me that developing a "skilled" climate forecast requires a lot of data. First, they do hindcasts, looking at predictive ability of the models using past data. Then they look at forecasting. The next challenge, they said, is to scale

these down to the local level. I was told that while the climate models could potentially provide a useful forecast across a broad scale, to focus medium- to long-range forecasting down to the local district level was extremely challenging.

Summary and insights from Case Study 1

The findings from this project highlighted some key questions and issues that I used to inform my ongoing exploration of the literature, theory synthesis and the two subsequent case studies. From the preceding findings narrative, I have summarised some of the key insights that helped to inform and generate the five principles for the transdisciplinary methodology that I propose in this thesis.

Principle 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity.

The first challenge in this project was problem definition. There are two questions that I draw from the project objective statement. Firstly, what is (or could be) the link between food security and seasonal climate forecasting, and how might this reduce agricultural production risks? Secondly, how can any resultant forecasting system then be applied as a blueprint across other parts of India and Sri Lanka, and more broadly across other countries in the Indian Ocean Rim?

This highlights the breadth of the contextual base, and the magnitude of the task required to gain an understanding of such a complex, broad ranging context. Apart from time and funding constraints, I propose that the required logical framework approach to project design limited the scope for development of a comprehensive and diverse contextual picture on which to base the problem definition for the project. I do not suggest that log frame approaches don't work or are always inappropriate, but that they may not be sufficient in such a complex project.

This prompted me to re-examine the research literature, with a particular focus on the complex systems literature, to investigate theory and practical options for enhanced approaches to complex problem framing, and in particular addressing wicked problems.

Principle 2: Co-production of knowledge across the boundaries of knowledge cultures and worldviews requires an inclusive shared language for human and social enquiry.

The "wicked problem" nature of the complexity made the project challenging to manage. The various groups within the project were working at multiple scales, with multiple disciplines and other knowledge cultures each pursuing different lines of inquiry, and seeing different views of the world. The response of the project leadership to this challenge was to disaggregate the project into a series of work packages and sub-teams. While this enabled a more time-efficient project (particularly given the constraints of travel and distance), this also had the potential to limit the ability of the participants to take a more collective approach, and to achieve co-production of knowledge across the boundaries of these knowledge cultures or disciplinary groups in this case. This provided me with background questions and insights that eventually led to the development of Principle 2.

The diverse nature of the questions posed by the informants (see examples in the earlier part of the chapter) did not always correspond to the scope of the project and were not easily translatable by other participants from different disciplinary backgrounds. Here it tended to result in a series of parallel inquiry processes.

The Sri Lankan researchers did describe a co-production process, and a strong collaborative process amongst themselves and the diverse set of stakeholders within their own country (particularly the INGO with whom they had a long-standing partnership). They described to me how they were a group of friends from student days, and despite different disciplinary backgrounds, had worked together over many years. They also talked about the linkages they had built with other development actors, rural communities, and government agencies (including key policy players). They described trust and long-standing relationships as key to this.

This also raises questions about the possibilities of an inclusive shared language that would foster co-production of knowledge across diverse groups, and to establish these links across knowledge boundaries (e.g. farmer and climate forecaster). Again, I looked to the literature on collective and social learning, co-production and evolutionary

learning and transdisciplinary research, to inform theory and data collection for my thesis.

Principle 3: Working constructively with tension is a catalyst and foundation for transformational learning and change.

As the narrative describes, there were various lines or sources of tension within the project. This included the paradoxical nature of livestock inclusion in rural systems, as well as the tension between the vast differences in scales (from farm household through to Indian Ocean Rim). This paradox and other forms of tension in the project context appeared to add further complexity, and prompted further investigation of the literature about the nature of these tensions and the theory and practice associated with them.

Principle 5: Reflection and reflexivity (both habitual and systemic) are essential to enable the researcher to constructively capture transformational knowledge co-production.

There was a strong focus on encouraging reflection on the part of the participants (in the project plan and as a key part of the evaluative work package). I did not participate in this section of the project; however, it highlighted to me the importance of reflection, which prompted further investigation of the literature around reflection and reflexivity.

Case Study 2: Food and nutrition security through family poultry and crop integration in Tanzania and Zambia

The second case study allowed me to further investigate questions and insights from Case Study 1, as an ongoing part of the iterative approach. This project also focused on a transdisciplinary, complex systems approach. This second case study enabled me to develop the frameworks for the five principles for a uniting transdisciplinary methodology, which I then applied to the analysis of Case Study 3. Case Study 2 provided insights into Principles 1, 2, 3 and to a lesser extent Principles 4 and 5.

In this section, I outline key findings from Case Study 2, and conclude with a summary of insights and learnings in relation to each of the five principles.

Involvement and data collection

I was involved in the project from the beginning of the scoping study, through to the final project signoff by the funding agency. As a participant observer in this project, I had a multiple role, including as a team member assisting with gathering information for the scoping phase. I also assisted with the drafting of the project proposal, in particular, the development of the communication and knowledge management strategy.

My project interaction included a series of meetings and visits to the campus of the university that was the commissioned organisation (or lead) for the project, to meet with the Australian project team, as well as two visits to Tanzania to meet and consult with potential project partners and to gather information and background for the full project proposal. The second trip to Tanzania included a field visit to two provincial government offices as well as local rural communities, and concluded with a final scoping study workshop. I interviewed 13 participants, of whom seven participants were interviewed more than once. The interviewees included members of the scoping team (most of whom became members of the project team). This included the Australian and Tanzanian team members. These included university researchers, participants from the INGO, and national government staff and researchers in Tanzania. I also kept an extensive diary of my participation and observations as well as key documents associated with the project.

Project background -- revealing the "iceberg"

The descriptions of this project by its participants revealed a picture of an "iceberg" – with the current project visible above the surface, and a huge hidden mass beneath which is the previous research and development history. While the project was focused on family poultry production integrated with cropping in Tanzania and Zambia, it had a very long and extensive underlying history. The project leader and her INGO team had been working on village poultry and disease control (particularly Newcastle Disease control) over more than 20 years in Africa as well as a number of other parts of the developing world including Asia and Latin America.

Village poultry are found in all developing countries. They are important in poor and vulnerable households from a range of perspectives, including as sources of meat and eggs, for pest control and manure, and in festivals and ceremonies and have been linked with wildlife conservation initiatives (Alders & Pym, 2009; Alders, 2012). One of the participants described village chicken like "*an ATM in the backyard*" adding that a chicken could be easily traded for family needs such as medical treatment, clothing and school fees.

Village chicken production systems are generally low input and low output. The birds require minimum housing and husbandry. They roost in trees, scavenge for food and are generally quite hardy. Village poultry are mostly owned by women and children (Alders & Pym, 2012), and the project proposal states, "*Research indicates that resources under the control of women are more likely to be used to support the education and nutrition of children. Thus it is hypothesized that improving women's production of family poultry and crops can have a beneficial impact on children's overall nutritional status and health.*"

According to the project plan, "*Newcastle Disease is considered the most important poultry disease worldwide*" and the project leader and her colleagues had successfully developed a thermo-tolerant Newcastle Disease vaccine, which is cheaper to transport and store than most vaccines, and more affordable and accessible for village smallholders. Previous projects had focused on sustainable control of Newcastle Disease using thermo-tolerant Newcastle Disease vaccine through local production and administration by community vaccinators.

CS2J described the background to the project saying, "*we are bringing in 15 years' work, and 15 years' experience in the region in all aspects. Because we have been more involved in development and less in research. [At first] it was more about showing that Newcastle Disease control was effective, and less trying to see its impact. So now it is the notion of impact that we are very enthused, it has not been studied*."

"*My vision of success is to bring all this experience and this knowledge, so many years of experience, and adding the health aspect and the agricultural aspect to it. … looking at the poultry production in a more holistic way, and adding the human health and the ecology*."

She added that the core members of the project team had been working together for a very long time – in some cases 30 years – "*so we are building on long-lasting relationships and long-established relationships that are very effective and strong and sound and deep … we are looking at different sections of the process, improving livelihood, improving security, fighting against poverty, so each of us, each specialty, each field of expertise has already an understanding.*

CS2J emphasised the importance of continuity and being able to build on previous projects, and reflected on her frustration with earlier work in post-war rebuilding and development in an East African country, "*But I was not seeing anything working, and I was not seeing the possibility to think on things in a consistent way, with people who had a sound interest in the things we were doing. Because everyone was employed by an organisation for the first three years, then moving on to something else. No continuity, no philosophy, no real engagement with whatever people were doing*."

CS2J also reflected on the importance of including farmers as equal participants in the project. "*Yeah, [the farmer] as a source of knowledge. And as people who are able to take decisions about how to improve their own livelihood, and also explain to us why they are doing what they are doing, and the way they are doing."*

The project was started at a time when there was a strong push globally to cross the boundaries between development work in agriculture and in nutrition. The project plan quotes a DFID report that "*identified eight clear research gaps that must be addressed in order to bridge the connection between agricultural interventions and human*

nutrition" (Hawkes et al., 2012). In addition, the more recent rapid spread and serious nature of highly pathogenic avian influenza subtype H5N1 has reinvigorated the focus on village poultry health.

Project design

The project focused on family poultry production in Zambia and Tanzania, and took a systems-based approach – looking at cropping and poultry production as a potential integrated system, and linking this to child nutrition. The ultimate aim of the project was to improve nutrition in children in rural villages through an integrated approach to the complexity of food security and nutrition in children. In particular, the project proposal was based on a "One Health[3]" approach, quoting the interrelatedness of poultry and human health particularly with the rise of H1N1 Avian Influenza and ongoing challenges with poor nutritional outcomes with children in rural villages in both Tanzania and Zambia.

The project plan justification stated,

> Under nutrition is a result of complex causes and to date little research has examined nutrition-specific, health-based approaches in collaboration with food system and livelihood-based interventions. Crucially, supplying women of childbearing age and their children with sufficient calories is important but it is not enough to optimise epigenetic programming; the proper balance of micronutrients is also essential for both short- and long-term health.

[3] One Health principles are designed to transgress the barriers between different disciplines and domains to create a more systemic and interconnected approach to dealing with all aspects of health care for humans, animals and the environment. This encompasses veterinary science, medicine, environmental health and public health (Monath, Kahn & Kaplan, 2010; Zoonotic Disease Unit, 2012; Mazet et al., 2009). Mazet et al. describe the One Health approach as being transdisciplinary since it is dependent on a wide range of disciplines to achieve outcomes for human and animal health (2009).

The project had four objectives:

1 Assess the existing family poultry-crop systems and value chains.
2 Test appropriate interventions for improving the integration and efficiency of family poultry-crop systems and poultry value chains.
3 Assess the role of women and impact of improved family poultry-crop systems interventions in childhood stunting.
4 Support capacity building of, and catalyse strategic long-term partnerships between key institutions and individuals associated with family poultry, food security and sustainable agriculture.

The three anticipated impacts were:

1. Improve food and nutrition security in project communities by improving the quantity, quality, accessibility and utilisation of food at household level.
2. Demonstrate the benefit of a multidisciplinary approach in engaging all key sectors from national to community levels in implementation of the project and seamlessly integrating social science research into project activities.
3. Provide a cost-benefit analysis that will underpin decision making at the policy level to support agricultural interventions as a means to improve food security and prevention of nutritional stunting.

CS2E spoke about her perspective on the project and its objectives and how the project would build on earlier work, *"… one of the things that I've been interested in … during that time is we'd been saying that Newcastle Disease control leads to improved livelihoods through improved village poultry production. And certainly there is anecdotal evidence in the field when you go out and you talk to farmers … we hope that [this project] is going to provide some way of looking at the particular means and ways in which this food security has been improved. And you know, it will give us an evidence base for that.*

"And the penultimate dot point for selection criteria … should be something like 'and make yourself redundant by the end of the project'. But we haven't been able to do this up until this stage alright, we've been trying, but you know, there are big problems in southern Africa."

Dealing with complexity

The design of the project was challenging and highly complex. For a start, the team members were trying to ensure that the interventions (introducing the Newcastle Disease vaccine) were happening where there had not been nutritional interventions previously. This was extremely difficult in a country like Tanzania, where nutritional interventions are very widespread from a very wide range of donors. CS2F spoke about a major food fortification program being rolled out by one of the UN agencies, which would be fortifying (with micronutrients) maize flour and oil that could potentially confound the current project. "*Those programs are there and will contaminate our study and create a lot of background noise,*" she said.

Added to this was the challenge of having what CS2F called "control villages" where growth measurements and blood samples could be taken from children as a comparison. For CS2F, one of the key problems she worried about in the project design was establishing adequate sample size to ensure statistical significance for the quantitative measurements of improved nutrition in children (such as weight, height etc.) in the project. Sampling was also an issue, from a classical public health research methodology perspective. But her biggest concern was an ethical one.

CS2F said, "*Another issue … is the ethics issue, because you can't hold the control village for too long if the chickens keep dying, but we're still taking measurements from their kids! So how are we going to handle this?*

"And because of so many things changing, you may never know the end result is of what. The complexity of it all! … If we focus purely on the scientific study design, the goal is to look at the effectiveness of one intervention, and then you need to control everything else as much as possible."

CS2H added another concern, "*I am thinking in terms of education about nutrition because sometimes people fail to meet their nutritional needs because they don't have the knowledge. They may have a lot of food around them but not know how to make a balanced meal.*

"*And at the moment, there is a global nutrition scaling up, intervention,*

supplementation and all that. And I don't know how we control for that, the village executive officers will take the opportunity. They will not want to refuse, which is good. But I don't know how we are going to go about it."

Added to this, the project team had decided to include a second country – in this case Zambia – but during the first field trip, several of the team including CS2F had had a somewhat frustrating experience during their visit there. "*Last week in Zambia, the organisation wasn't so good; because the government staff was distracted preparing budget papers. Last week I wouldn't say was wasted time, but I was worried if Zambia was ready for a complex program like this … the second issue is the vaccines, the field trial is not completed yet so the vaccine in Zambia is not registered yet*."

A number of the team members I interviewed (all of whom were very experienced field workers) commented on the difficulties of engaging with farmers and at the village level in these countries and the kind of expectations that this can create.

CS2E talked about the dangers of making assumptions in research for development. She said, "*[we need to] look at many of the assumptions that we'd been making for a long time, and seeing whether the reality on the ground, … you know, the farmers that we deal with, whether it's their reality and their understanding as well …[and] this project is a an opportunity to look more in depth in a more balanced and structured way. Now that I think is really important*.

"*There are a number of assumptions that … village chickens are important for poor people, they contribute to livelihoods through all these particular various aspects that they're used for, that they're frequently managed by women. We realise that sometimes things are different on the ground, particularly in Africa … when there is a possibility of funding or goodies involved, then people's realities do change*."

She gave the example of the problem of per diems and workshops. (Per diems are a daily payment for out of pocket expenses and travel and accommodation costs for local researchers and government staff to attend workshops or meetings.) "… *Understandably the salaries are so poor that it is a way of supplementing the salary, but it is causing problems with productivity. So my wise friend decided to take the 'H' out of workshop and make it into a 'T'. But yes, the handout mentality is there at all*

sorts of levels, and it's hard to deal with, and it is particularly when a white face comes in."

On the other hand, CS2H, one of the Tanzanian project team members pointed out that for some of the district and local government staff, the project would provide them with an opportunity to visit and interact with villages across their districts. CS2H said, "… *for the district officials, this project actually gives them the opportunity to manage to reach some of the areas, which they didn't reach, because of the limited resources, no money for fuels, so they can't.*"

CS2H also talked about one of the local village nurses (who ran the local village dispensary or health centre) whom we had met during the field trip, and how important such women are to their local communities and how critical they would be to the project.

"*Yes, [the project] will definitely help people like her, and other village executive officers, extension workers, village health workers … it will make them more recognised by the people. It will help them see their own contribution. … An important thing is to get them to feel that the project is theirs. Let them just feel the ownership."*

Funding and access was also an issue at the national level as CS2H recounted. "*I think one of the challenges for us is that we are limited with the funds and resources. We normally reach a certain type of district, based on donor interests.*" She went on to explain that the choice of districts and villages for the study was being vigorously debated by the in-country government partners, and would take some time to resolve.

Bridging disciplines and other knowledge groups

The project was led by an Australian university, with the inclusion of an international NGO, and various other international universities, multilateral organisations and regional organisations, as well as government agencies in the partner countries.

The project team consisted of a wide variety of research disciplines, including veterinary science, public health, epidemiology, human nutrition, cultural anthropology, agronomy and crop systems, ecological economics and ecology. In addition to the researchers, there were government service delivery staff, policy actors, district and

local government health and agriculture staff, and a number of international development practitioners as well as the villagers themselves. The project was designed to operate at multiple levels, from pan-African organisations to national level, to district and right down to the village level.

For CS2F, a public health researcher, this project opened up a whole new area of research, "*… This was a relatively new concept to me, because until now, basically since I had only dealt with pure public health model, and not really integrated with other areas or sectors. For example in the past, I've been involved in fortification and supplementation of micronutrients, so [this project] is rather taking the holistic view.*"

A number of the researchers talked about the ongoing tension between the desire to have statistically significant, quantitative data on nutritional outcomes in children based on the interventions, and on the other hand the ethical considerations of delaying the interventions for the so-called control villages when they may already have evidence of malnutrition in the children. This was also made more complex by the sheer number of factors and variabilities they were dealing with.

The difference in approaches and methods created a kind of tension for the project design which a number of the team members acknowledged in their interviews. CS2F said she had pondered this a great deal, "*If this is a development project, then you probably shouldn't expect to find scientific outputs and outcomes. And if it is a research project, you shouldn't compromise too much and try to accommodate the development. I wouldn't call it a conflict, but something we have to work out to find a middle point, for all parties to be comfortable with … I am just saying some things have to change.*"

The challenge of bringing together similar disciplines, in this case public health, medicine and veterinary science, was highlighted in discussions relating to data collection and measurement. One disciplinary group use standardised measuring equipment that is internationally certified and approved. This means there is a price premium. The other disciplinary group suggested that the project could save money by purchasing non-certified equipment at a cheaper rate. For the first group, this was an issue of "*sticking to disciplinary standards*" and "*ensuring validity and rigour*", whereas the second group did not see that use of different equipment would make a difference to either of these, but instead were focused on managing budget limitations.

In this case, neither group is necessarily wrong about what are acceptable questions and procedures.

The project leader was well aware of the challenges associated with the variation in "languages" of the different disciplines. One of her strategies to mitigate communication challenges associated with language difference was to create a glossary of terms and definitions. She told us that this way we could then have a reference and a common set of terms so we could begin to share a common language.

An example of this was particularly highlighted in a planning meeting held during the second scoping visit in Dar es Salaam. The discussion centred on protein sources in village diets, and the importance of chicken meat and eggs.

CS2I described the challenges in one of the planning meetings during the scoping study. "*Well we started getting into semantics between different disciplines, like the use of the term high quality protein for animal protein and for a nutritionist, they don't use that term. So now we end up in conflict. We use language to describe something, but if you multiply that into different languages and … we find we use terminology that the other person will interpret in a different way.*"

He went on to describe the concept of "wildlife" and the difference between the Western definition and the definition within much of African culture. *"… They don't think of [wildlife] in a renewable sense, it is just there to use. And in their language, wildlife is what you put into the market, or what you put in a zoo, captive animals. What they consider nature is forest life, so they equate a forest with a natural system.*"

CS2L talked about bringing together all the " *'-ologies' – all special disciplines have to have their own jargon. But when you are working in a transdisciplinary team, …each ology has to sacrifice some of the niceties and distinctions … or you find that people get polarised very quickly and can't let go. Most of the time I think that there are very few definitional issues that are critical.*"

CS2L went on to talk about kinds of knowledge outside of the disciplines and the vast differences in viewpoints and understanding. *"[My friend] uses a phrase 'looking from the other side of the river', which I find a powerful analogy. So you have to understand the perception from the other side of the river. [And that takes] humility and patience.*

And I think one of the things we do in training scientists is we train them too narrowly."

CS2M talked about the challenge and dilemma of the expectation that quantitative evidence is needed for proof. "*Every scientist wants proof … so five thousand people say 'we are so much happier now, we've got chickens', but what does that mean? Quantitatively, how much better off are they? Do they survive better through drought? Is their children's nutrition better? Are their iron levels better? Is there less stunting in the growth of children? And how, what the best indicators are is going to be a huge trial to work out. And a five-year period is actually a reasonably short period too … There are so many dilemmas about getting quantitative data for a project of this nature, which is why we have never done it. And it's a lot of money to do something that is really proving the obvious, but proving it for dissenters I guess*.

"*… probably the most important aspect of this work is the communication strategy. … And make the information widely available to all and sundry at all levels. You are looking at government decision makers. You are looking at agricultural extensionists. You are looking at government veterinary laboratories. You are looking at the villagers themselves*."

Paradox emerging from complexity

A number of the participants discussed the challenges of coming up with an agreed set of desired outcomes, and that a positive outcome in one aspect of the system may cause a negative impact elsewhere. An illustration of this was the discussion around whether increasing chicken production was a core goal.

CS2J said, "… *maybe I was afraid at the same time when somebody commented that we produce more chicken, we are going to lower the price of the sale, and the person who was saying that was seeing this as a major achievement and I said maybe we will decrease the possibility of empowerment of the rural people*."

CS2I spoke from a more ecological perspective saying, "*And when you look at a [European] production system, everything is oriented towards producing bigger and more of it*."

"*But if you look at an industrialised poultry system, it's like a pathogen factory. You've multiplied pathogens, that can then enter the food chain … The system's a failure because we produce very, very serious pathogens, despite our so-called biosecurity systems. So we need to reflect and review on more traditional systems and say – what actually are the input costs to that system? What are the outputs?*" This illustrates the challenge of dealing with a wicked problem – what seems like a solution from one aspect of the problem, leads to unintended consequences elsewhere.

CS2I talked about the systems associated with poultry production and consumption and the broader field of food security. His veterinary background was complemented by his work on wildlife, conservation, environmental issues and looking at disease proponents in both animal and human systems. He talked about the paradoxes associated with the domestication of livestock. *"… actually, if you look at the history of disease, many, many of the common human diseases are derived from the domestication of animals … so the domestication process of livestock is what created the evolutionary opportunity for these diseases to emerge. And this is also true of livestock diseases. They are actually a product of the system that we designed."*

CS2I said, *"… there's a thing called Jevon's paradox: showing that increased efficiency doesn't necessarily lead to the outcome you want. Because if we are within a finite resource base, increased efficiency leads to more consumption. So that's a paradox.*"

Communication challenges

The final project plan contained a communications strategy that was written and facilitated by CS2J and me. The strategy states, "*the complexity and transdisciplinarity of this project requires new ways of interacting and working to transition from a multidisciplinary approach to a transdisciplinary approach*."

This aligned with the planned scientific impacts in the project plan that state, "*the effective integration of these key elements will provide evidence for the benefits of adopting One Health and transdisciplinary approaches to solving complex field problems*". Note that while the project plan generally refers to "multidisciplinary approaches" there is a clear aspiration to "transdisciplinarity" per se, as well as

promoting improved methodology and practice for transdisciplinarity. The communication strategy had strong support from the project team (and particularly the team leader), who saw how important effective communication would be, particularly in "*fostering an open-minded and inclusive approach to different methodologies and viewpoints; and to ensure they were taken into account in decision making processes; support mechanisms for iterative reflective and evaluative approaches for ongoing learning and adaptation, as well as identifying and learning from emergent ideas and strategies*" (Communication Strategy Appendix 1 of the Project Plan). The strategy also talks about providing a "safe space" for participants to share ideas and discuss and resolve tensions and issues. The strategy acknowledged the importance of engagement and participation of a wide range of stakeholders, from the local through to the pan-African level. The strategy states:

> For communication in this context to be success, there is a need to:
>
> - Create shared meanings without losing the richness of the various communities of practice with whom we are partnering
> - Build a framework for collective knowledge creation and sharing
> - Leverage different viewpoints, ways of knowing and perspectives to create a coherent whole …
> - Be open to new practices and methodologies.
>
> (Bagnol et al., 2016)

Summary Case Study 2

While the findings from this case study project provided a different perspective to those of Case Study 1, Case Study 2 further supported the emerging themes and principles. From the preceding findings narrative, I have summarised the key insights that furthered my development of the five principles for the transdisciplinary methodology, thus forming the second stage of my iterative, adaptive inquiry approach.

Principle 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity.

The depth of the background knowledge, experience and assumptions highlighted for

me the importance of having an inclusive, appreciative and deep understanding of the context for problem framing in a project. The first section (Project Background) highlights 20 years of research and development underpinning this particular case study project. In addition, the findings from this case study reveal a deep complexity with multiple factors and interactions. They also demonstrate the characteristics of a wicked problem, where one solution can create unanticipated and at times negative impacts somewhere else in the system, and causal links are tenuous at best. Where there is no final solution, but a series of ongoing partial solutions, which is clearly demonstrated by the length of time this particular "group" of researchers have been working on village poultry.

The design of the project proposal was immensely challenging, as there were so many different facets and fragments to pull together. Aligning the various viewpoints and capitalising on the diversity and depth of knowledge was a huge challenge. Reflecting on this, I began to explore an inclusive appreciative framework to achieve this through the wicked problems literature. I adapted Ashhurst's six dimensions of wicked problems to use as a tool for problem identification, which I describe in Chapter 3. I test this framework in my analysis of Case Study 3 in Chapter 9.

Principle 2: Co-production of knowledge across the boundaries of knowledge cultures and worldviews requires an inclusive shared language for human and social enquiry.

The findings narrative for this case study provides examples of the tensions and conflicts that arise when different disciplines, worldviews and knowledge groups are brought together into a team. The findings highlight the challenge of different language, more complexity, and the need to take into account alternative views and approaches all in one project proposal. While some of this can be ameliorated through good communication strategies and team work, I assert that there are fundamental differences which require novel approaches and synergy.

With this in mind, I returned to the literature to explore concepts such as co-production of knowledge, social learning and finally collective learning approaches, identifying the five doorways to understanding as a common and inclusive shared language for human and social inquiry. I outline the theoretical basis of this in Chapter 5, and I test the

framework in my analysis of Case Study 3 in Chapter 10.

Principle 3: Working constructively with tension is a catalyst and foundation for transformational learning and change.

The different disciplines and their different perspectives and methods created significant tension (and occasionally some conflict) in the design process. One of the key tensions raised was the challenge of collecting and analysing data that would be statistically viable for quantitative analysis that was counteracted by the very serious ethical challenges of having control villages where the intervention was delayed. There was a constant push-pull between these two concerns, resulting in a very complex fieldwork design.

Added to this was the paradox of promoting low input, low output village chicken in a research and development environment that measured dollar value and increasing production as its goals. And the ongoing debate about whether higher production levels mean a lower price and hence lower income for village producers – a positive result leading to a negative result.

Added to this is the paradoxical situation where apparently successful industrialised livestock production is promoting the emergence of major pathogenic threats not only for livestock but also for humans and is labelled a “failed system” by the veterinary and wildlife ecologist despite the goal of providing food security. This ecologist draws a parallel to Jevon’s paradox, which states that increased technological or production efficiency actually increases the consumption of resources rather than conserving them (Alcott, 2004; Polimeni & Polimeni, 2006).

The presence of tension between ways of knowing and understanding and the presence of potential paradoxes prompted me to look at the literature with a particular focus on the work of the anti-dualist pragmatists, and to explore concepts such as pattern mismatches, double binds, paradox and dichotomies as an inherent feature of highly complex systems and wicked problems.

Principle 4: An iterative or recursive research inquiry process is essential for transformational learning, and for theory and practice to inform each other.

This second case study highlighted the importance of an iterative or recursive approach in my own thesis research. At this stage, I reflected on my own recursive path from theory to Case Study 1 back to theory and onto Case Study 2, as the themes and theoretical frameworks began to form more clearly.

Principle 5: Reflection and reflexivity (both habitual and systemic) are essential to enable the researcher to constructively capture transformational knowledge co-production.

The researchers I interviewed in this case study were highly reflective and at times reflexive. The findings suggest that they questioned their own assumptions and their role in the project. I assert that this is at least in part because of the complexity and intractability of the project and the challenges the participants faced in the scoping and designing. I also assert that the focus on reflexivity was important in creating a more inclusive and collective approach to the research design. The findings from this case study prompted me to look at the literature associated with reflective practice in research, and to further investigate approaches and conceptions of reflexivity.

Case Study 3: Developing multi-scale climate adaptation strategies for farming communities in Cambodia, Lao PDR, Bangladesh and India

Case Study 3 is the final case study for this thesis, and forms the proof of concept for the five principles for a uniting transdisciplinary methodology that I propose. In this section, I outline key findings from Case Study 3, which includes a summary of insights and learnings in relation to all five principles. This is followed (in Chapters 8 to 11) with an in-depth analysis of the case study data using the example frameworks from each of the five principles.

Involvement and data collection

I came into the project towards the end of the first half of the project, just prior to the mid-term review. I continued my involvement and observation until the final review of the project (prior to the completion of the project). My role in the project was that of informal reviewer/observer, though I emphasise that I was not there to provide an evaluation of the project, but rather an appreciative study, yielding insights for future projects and processes.

The key events I was involved in were:

1 The project mid-term review
2 Project review and second half planning meetings in India
3 Final project meeting (held in Lao PDR).

The first and third event included participants from all five countries and from many disciplines. The second event was focused on the Indian participants, with the Australian leader of the Indian component present.

During this time, I interviewed 16 participants, and four of these I interviewed twice at different stages of the project. My interaction with the project included various meetings with the participants in their Australian offices, review and planning meetings, and field visits in Cambodia, India and Lao PDR. I was also given access to a wide range of project documents, including the project plan and various amendments, selected trip reports, journal papers and reports (including annual, mid-term and final reports). The

external reviewer reports were also shared with me.

Project beginnings

The project was conceived as a way of addressing long-term climate change through a series of technological tools as a means of helping farmers (particularly smallholders) to mitigate climate risk and develop adaptation options in these farming systems. The project leader described it as an ambitious project (spanning four countries) with a well-funded scoping study.

The scoping study for this project began in the early days of the then Australian Labor Party government as part of the aid program's climate change adaptation initiative. The brief was to develop a project that leveraged some of the climate and weather forecasting tools that have been developed in Australia and internationally, as well as using the crop production decision support tool, APSIM.

But the scoping study quickly revealed a problem – smallholder farmers are not interested in planning for 2030. They have more immediate problems of survival and adaptation, and often it is not about climate. The second issue the scoping study cast up, was that adaptation is largely a social problem rather than one to be solved solely with technological fixes. And most adaptation interventions in the development field tended to focus on technical issues and solutions, downplaying the importance of the social dimension of adaptive capacity (Roth & Grunbuhel, 2012).

The project participants (informants for my thesis) described to me the debate between the funding agency and the project team about the framing of the project. From the funding agency perspective, they were tasked with delivering on a policy direction regarding achieving outcomes in relation to climate change adaptation (among other things) whereas the project team was finding the reality on the ground called for an adapted approach that reflected the reality they were experiencing.

One of the problems highlighted by a number of the participants was the rapid changes taking place in rural systems in the target countries, and the impossibility of predicting what future farming landscapes were likely to look like in 2030 or 2050 (the proposed timeframes). In addition, it was pointed out to me that climate adaptation is just one of

the many drivers of change for farm families and farming communities and that there were far more pressing issues and drivers requiring immediate decisions for adaptation and even simply coping mechanisms.

Participants also talked about the lengthy debate between the project team and the funding agency about the focus of the project. The team wanted to focus on a livelihoods approach, but this was seen as insufficiently focused and not sufficiently distinct from other projects. In addition, the agency, which has a reputation and track record for practical scientific and technical solutions and outcomes, was pushing strongly for a more technically-based approach. There was further discussion about scope given the inevitable overlap with food security and the subsequent establishment of a food security focused project in the same countries.

The development and implementation of the project was also challenging because of frequent changes of personnel in the program management office of the funding agency. Unsurprisingly, successive program managers had different views of the approaches and focus the project should take. In addition, a change of government mid-way through the project brought about a radical shift in Australian Government policy, with climate change and climate adaptation largely taken off the agenda and significantly downplayed in international development work.

Project design

The aim of the project was to “develop multi-scale adaptation strategies and demonstrate processes that enable policy to deliver more effective climate adaptation programs relevant to smallholder livelihoods and food security” (Roth & Grunbuhel, 2012, p. 428).

The objectives included:

1. Adapting and applying available tools/methods to select and assess adaptation strategies for rice growing
2. Developing research and extension capacity and processes
3. Selecting, evaluating and providing a suite of crop, nutrient and water management adaptation options for dissemination

4. Determining principles and policy recommendations for better design and implementation of adaptation strategies at multiple scales.

The proposal outlines a four-stage research strategy, including:

1. Determining farming system typologies, and adaptive capacity
2. Scenario modelling and farmer consultation to develop adaptation options
3. Testing options temporally and spatially
4. Scaling up through engagement with policy stakeholders.

The project was designed to include five countries – India, Bangladesh, Cambodia and Lao – with varying emphasis on activities between the four as well as Australia as the lead partner. The proposal also talks about linking to other related projects in various countries.

The initial project proposal clearly highlights one of the fundamental challenges of this project – the requirement to work at both the national policy scale and also at the local and household scale. In the project plan, this is described as the "*tension between national level and local level adaptation studies*". The proposal continues, stating (in reference to the tension described above) "*This gap constitutes a unique investment opportunity [for the funding agency], allowing the project to be clearly differentiated from other research and development initiatives in climate adaptation*". The project proposal highlights a unique niche for itself in bringing together seeming polar opposites – national-scale climate change vulnerability and household and community level assessments and interventions. The initial project proposal talks about the need for "*tested and robust crop and water management options that will outperform existing farming practices*". But the proposal also states, "*The project will bridge the gap in these countries between national scale climate change vulnerability and impact assessments, and adaptation interventions at the household and community level*."

This highlights the kind of ambiguity and tension that is created through working across multiple scales which allows for more diverse interpretation and opportunities for learning and novel thinking.

From the outset, the project was designed to span a broad range of disciplinary areas that was at various times called "integration", "systems science" or "transdisciplinarity"

by members of the team. This included a clear focus (stated in the project plan) on using a "*systems approach to strengthen the ability of research institutions to overcome disciplinary boundaries and to strongly engage in systems level research*."

The project also goes beyond economic benefits and impacts and highlights a broader suite of values according to the sustainable rural livelihoods framework (Scoones, 1998), including personal and community capacity, security and well-being and particularly social capital.

The section on communication and dissemination activities provided a very broad listing of stakeholders with whom the project team needed to interact and who had influence or were beneficiaries of the project.

Disciplinary work and groupings

The proposal highlighted a gap in the climate adaptation research at the time, which was the lack of work at the cropping or farming systems level. In particular, the need for simulation models for rice-based farming systems and integration with the social sciences, as well as weak capabilities in interdisciplinary and systems sciences.

To address the lack of simulation models, the project included APSIM (Agricultural Production Systems Simulator), a module-based software modelling tool used to predict cropping processes, including plant, soil climate and management processes (Gaydon, 2014, p. 15). This model, or simulation tool, is designed to be an "open source framework" to bring together information from fragmented research. Current uses listed include greater understanding and prediction of production and resource management, crop rotations, climate impacts and adaptations, leaching, draining and effluent, soil nutrient management and irrigation (Gaydon, 2014, p. 17–18).

Because APSIM did not include rice-modelling capability, the researchers had opted to create a hybrid with ORYZA, another computer program which simulates the growth of rice crops and which has been developed by the International Rice Research Institute (IRRI) in the Philippines. The researchers described the APSIM crop-modelling package they were working on as very data hungry. A significant tranche of the project activities was focused on generating data to feed into the model to improve predictive

capability.

The project team varied in size over the life of the project, but at one stage, numbered around 60 people. This included a wide variety of research disciplines, and quite a few who identified themselves as practitioners. The disciplines listed in the project participants list included soil and water management specialist, social anthropologist, rural livelihood specialist, climate change scientist, APSIM modeller, agronomist, agro-meteorologist, climatologist, spatial modeller, extension specialist, farming systems specialist, agricultural economist, animal science specialist, animal husbandry systems specialist, social scientist, entomologist, resource economist, and water management expert.

In their interviews, many of the researchers said that their official expertise and experience was often very different to what they actually did in the field. Many of them had started with a particular specialisation, and had gradually either broadened their knowledge base or shifted laterally into another area of expertise. In addition, current listings of disciplinary groupings (in universities and online research portals and networking sites) simply do not adequately describe the kind of work these researchers are doing.

Leadership and team formation

The project leader had extensive experience in international research for development and particularly good networks and contacts in South Asia. He placed a high value on the importance of relationship building and seeking local advice. The project leader reported that he was personally undergoing a transformational change in his thinking and learning about a more inclusive approach to knowledge creation – including social science and local knowledge.

This project leader talked about taking what he described as a fairly radical step in choosing his project team – he appointed a social scientist as his deputy. Not only was the new deputy a social scientist and very experienced in the South-East Asian context (and speaking a number of local languages fluently), he did not come from an Australian background, having only recently arrived in Australia. The appointment of a social scientist as deputy was a surprise to many of the team scientists, as they were

accustomed to biophysical scientists with established careers in Australian institutions taking leadership roles in these kinds of projects.

My first meetings with the Australian team were in the planning phase for the mid-term review. I found my introduction to the various members of the team warm, friendly and quite relaxed, and most of them were intensely curious about my research. The team members I talked to were enthusiastic and very positive about the progress of the project so far.

The first half of the project had been focused on identifying adaptation options, tools and strategies that could then be taken to policy makers at the provincial and national level. This was a huge challenge, given the diversity of the environmental and social systems they were studying.

While differences between India, Bangladesh, Cambodia and Laos were no surprise, the differences within a farming district or community were very marked. To deal with this, they used the sustainable livelihood framework approach (Scoones, 1998) to structure their questionnaires and to develop household typologies that were presented at the mid-term review. They had developed a series of farming household typologies to try to encompass the highly varied household systems they were seeing in their fieldwork.

In the meantime, the agronomy teams in each country were conducting field trials to look at options for production system changes and cropping options. They were also collecting data to calibrate APSIM and to construct the rice systems version of APSIM. In addition, the climate-forecasting team was working on gathering 30 years of climate data to construct predictive models for forecasting. The plan was then to combine the APSIM calibrated model and the climate models to provide a forecasting tool for decision-making.

All of this information was to be brought together, not only to provide options for farming households, but also to present to policy makers and develop implementation options at the national scale in each country.

Household typologies

The development of the household typologies is a central strand in this project, and is carefully explained in the proposal. It is an important element for the purposes of this thesis study, as the thinking and approaches to this changed significantly during the life of the project.

The initial typology development approach was developed using the Sustainable Rural Livelihoods framework (which it continued to reflect), but the aim was to develop types which could "*reflect cross-country commonalities, in order to create a general typology of Asian rice-farming systems*". The typology approach was also limited to creating a "snapshot" in time of the households.

A variation to the proposal (undated), suggests "*a deeper analysis of the relationship between adaptive capacity and farming systems typologies and how this relates to farmers' management of climate risk*". In short, the variation refocused on understanding livelihood trajectories rather than the snapshot.

In addition, the variation suggested a greater focus on the way institutions influence livelihoods. This reflects a clearer understanding of the tight connection between the social "enablers" which (for example) allow farmers to exercise options such as crop and water management options on their farms.

The authors of the variation (page 9) make a very convincing argument for deeper qualitative data collection by highlighting the limitations of focusing only on the "observable" and overlooking the subjectiveness of this. Instead, they suggest a qualitative approach to "*capture people's subjective experiences, perceptions and world views*", and include live histories, current livelihood strategies and considerations and perceptions of the future.

Integration

"*Cropping systems occur within a social context; without an understanding of this context, the outcomes of technological and biophysical interventions may be difficult to foresee or explain.*" This project proposal variation emphasises the process of integrating social and biophysical research as "*an important process and*

methodological venture in itself'.

I heard the integration theme and aspiration discussed and written about throughout my involvement in the project. There was considerable reflection and discussion about this, how well it was progressing, how it could be measured, and what it would mean.

The mid-term review meeting in Cambodia

The first major workshop/meeting I attended was the mid-term review meeting, which was held in Cambodia, and ran for nearly a week. This was a pivotal event for my study, given that it was the first time the majority of team members from the four countries had all been together, and because it provided me with an overview of the project so far. My role at this review, was as a secondary, informal reviewer/observer.

It was held in the ageing, once-grand, Hotel Cambodiana. At the end of the Khmer Rouge era, this was THE hotel for aid workers to stay when Cambodia once more opened its borders to foreigners. By the time of the review, it was well past its prime, showing signs of wear and tear but still with some vestiges of gaudy grandeur. The choice of this hotel among the many in Phnom Penh was largely because it was cheap, but also because it could accommodate such a large project team and host the more formal elements of the opening sessions with senior government representatives as well as Australian Embassy reps.

The hotel was located on the banks of the Mekong River, not far from the Royal Palace and alongside a number of much newer, more luxurious tourist hotels. The boulevard outside the hotel was unusually quiet, as the streets were still cordoned off following the funeral of King Sihanouk. We went to and from the hotel through a series of checkpoints and cordons.

At the mid-term review, team members from each country and sub-team travelled to Phnom Penh for a week. For many this was quite a momentous occasion, as it would be the first time they had all met up. The participants I talked to were excited about meeting fellow team members from other countries and learning from them as well as getting feedback on their own work. It was a big gathering and it took me most of the week to meet the various team members, and still there were some I didn't get time to

talk to.

The mid-term review was a huge challenge for the project leadership as they had a number of objectives that they felt were not necessarily completely compatible. The primary reason for the mid-term review (and the reason it was funded) was accountability based – to enable the funding agency to review progress and assure themselves that there was adequate progress on agreed milestones. To this end, they appointed two independent reviewers to go to Phnom Penh and produce a report. The project team had produced a detailed mid-term report ahead of the review that had been forwarded to the reviewers for reading prior to the meeting. The second, undocumented aim of the review was to enable relationship building, knowledge-sharing, evaluation, reflection and forward planning.

The mood at the review on the day everyone arrived was very upbeat with a buzz of excitement. There were gatherings in the hotel bar, and cafe and in the lobby as people met up and greeted each other. The project leadership was very preoccupied as they prepared for the arrival of the reviewers and did the final planning for the review meeting but still found time to greet various team members as they arrived.

The opening day of the review was very formal, with the official opening and speeches from local Cambodian dignitaries, as we were being hosted by the Cambodian partner organisations. The Hotel Cambodiana was an acceptable venue – as per protocol and local expectations and to accommodate the large contingent of researchers and to allow for the formality of the official opening and simultaneous translation etc.

Once the opening was finished, we got down to the process of the review. This was intensive – with a big lineup of presentations. There was a lot of discussion among the team members after the review that they would have preferred more informal time to network and share ideas and results, but the project leader was firmly of the view that the meeting needed to be carefully stage managed to ensure that the reviewers were provided with maximum information and exposure to as many different aspects of the project as feasible. He referred to it as "choreography".

Despite the steady flow of presentations and the intensity of the program, there seemed to be plenty of informal interaction, relationship building and information exchange.

Each evening, dinners were planned and people went off in clusters to explore the tempting array of restaurants in downtown Phnom Penh.

The second night, I joined the social scientists from five countries at a restaurant for dinner. It was a very jolly gathering with a lot of intense talk about different project activities, learnings, debates about methodologies and lots of exchange about the experiences in different countries. The local Cambodian colleagues brought their wives and children along and I learned that many of the families had got to know each other, and in some cases their children were now pen pals. I got a strong impression of people enjoying themselves and each other's company, and who were all passionate about their work.

At this stage I started to gain an understanding of the project progress so far. One of the main outputs at the time of the mid-term review, and one which the social science participants were particularly proud of, was the development of the farming household typologies. The typologies were designed as a means of capturing the diversity of household livelihood trajectories in the districts being studied.

Mid-week during the review, we travelled to Svay Rieng province for a field trip to visit some of the farms that had been part of the research, and to talk to farmers and local project partners. As we drove along the Mekong River, the wetter areas along the banks of the river were pointed out to me. This was the flood plain, which is enriched by flooding each season, and surrounded by levee banks which keep the houses dry. It was pointed out to me by two of our hosts, that there is a big difference for them between inundation and flooding. Inundation is expected each year, and is part of refreshing the cropping system, whereas flooding for them is unexpected and causes damage and property loss.

Once we crossed the Mekong on the ferry (an experience in itself), we came into what the Cambodians call the "dry area" of Svay Rieng. Cambodia receives one wet season or monsoon, though it comes in two "waves" with a "break" in between. Whether it is one or two wet seasons seemed to be unclear in discussions.

Our first stop was at a meeting of local farmers, local government and business and a large contingent of school children. The proceedings of the meeting were unclear to

many of us as most of the meeting was conducted in Khmer, and was largely focused on the reviewers. There seemed to be three distinct groups which didn't mingle – the farmers sitting along the side, the project team in seats under a marquee, and a large group of school children, also mostly in the marquee. The second part of the field trip was to visit a few farms. It was unclear to me what we were looking at or whom we were visiting. There were no active trials to see, and as we were such a large group (with the added language differences), talking to individual farmers was problematic.

The last day of the review included a reflection session for the team members. The team leader gave each participant a chance to provide his or her reflections on the project so far. In addition, there was a reviewer feedback session in which the reviewers spoke about their impressions and the initial findings of the review (which were circulated as a report not long after the meeting). I have included both the team reflections and the reviewer comments and review report in the findings and analysis in the following chapters.

The aims and conduct of this review process (the accountability and reflective, evaluative objectives) were much discussed amongst the project team. Many of the participants commented (both to me in interviews and in the review meeting itself) that they wanted more opportunity to reflect and review and share learnings and experiences with each other. I provide more detailed findings on this point in Chapter 11.

Following this meeting, a series of planning workshops were planned for each country. These planning sessions were a follow on from the mid-term review, and covered activities for the remaining two years of the project. The team had tried to include planning sessions in Phnom Penh, but they had run out of time.

Planning meeting in Hyderabad

The second major project event I participated in was the planning meeting in Hyderabad in India. Once the mid-term review was completed and the initial planning for the second half of the project, each country-based team then launched into more detailed planning. One of these planning sessions was the meeting I attended in Hyderabad.

The Australian scientist leading the Indian component of the project and I travelled to

Hyderabad for a week to meet with the various team members there. We spent most of the week at the university campus of the main research partner, but also interacted with the two NGOs who were involved in the project. The main topic for discussion was how to manage policy engagement as well as detailed planning for the other remaining components of the project.

The issue of policy engagement and policy options occupied a lot of time and discussion. There was not a clear plan for how to do this, or even who the key stakeholders were. I did not get a clear impression of how the team was planning to use the typologies, and the challenge of dealing at multiple scales was a taxing one.

I got a sense that the team felt as if they had only really just gelled as a working group, and now the project was rapidly running out of time. A number of the participants were regretful that there was no possibility of a follow-on project (since the donor was winding up their funding to this part of India). One of the participants said, "*As we get to the end of the project, we get brighter and brighter ideas! … And when there is no possibility for more projects*."

There was also discussion about how to engage women farmers more effectively, and a variety of views about the situation of women and whether and how much the project should engage in gender-focused issues. One of the discussions during the review indicated that some of the male project team members did not appear to be aware of the disadvantages suffered by the relatively small number of women farmers, nor did they appear to be aware of the kind of power asymmetries that exist between women and men in farming households in India.

Final review meeting in Savannakhet Lao PDR

The final all-country meeting of the project team took place in Savannakhet's provincial capital in Lao PDR (one of the participating countries). Participants from Lao, Cambodia, India, Bangladesh and Australia all came together for the second and last time to review the project progress. Two reviewers nominated by the funding agency were also present to provide a formal end-of-project review. Again, the focus was on the formal accountability and external review processes. Again, external reviewers were hired by the donor to provide them with an assessment of the project and its progress.

At the review meeting, there was substantial (formal and informal) discussion about the interlinkages and synergies between this project and others. For example, the APSIM modelling work was linked up across a variety of projects, organisations and countries. We heard about the contribution of the work at the International Rice Research Institute (IRRI) where around 30 years of continuous cropping data was feeding into the modelling and understanding of the dynamics of rice cropping systems. This connection had been facilitated through the personal contacts of the researchers, but had been reinforced by formally including one of the IRRI scientists into the project team along the way. The researchers talked a lot about their networks and the connections they made with other research institutes. A number of them talked about the challenges and difficulties of trying to establish the sustainability of the work they had engaged in during the project.

The project leader talked about his focus on finding opportunities to foster continuation of the activities and implementation of learnings from the project. He talked about the connections he was setting up with development projects, INGOs, policy makers, and other research projects to try to ensure continuity.

The project final report executive summary outlines key learnings from the project which I have included as follows.

> Key operational learnings include:
>
> - Creating an integrated, jointly owned research framework in the early stages of the project is critical for interdisciplinarity.
> - Detailed planning and review underpin sound project management, team integration and clarity of institutional and individual roles and expectations.
> - Participation and engagement by community and policy stakeholders supports relevance, validation, alignment and sustainability of project outcomes.
> - Investing in partnerships within and between project teams and disciplines is an investment in project outcomes, individual development and ongoing collaborations.
> - Setting clear aspirations for scaling and sustainability of project outcomes is as important as creating the flexibility to seize opportunities as they arise.
>
> Key research learnings include:

- Self-assessments of adaptive capacity reveal recurring indicators across countries, including health, level of education or knowledge, access to irrigation and livestock ownership.
- Household types and livelihoods analysis identified recurring drivers of change, including feminisation of agriculture, labour shortages and rapid rural change.
- A common framework (with a livelisystems approach) can be developed to explore adaptation options, allowing direct comparison between countries.
- APSIM-ORYZA has been comprehensively validated and is performing well in contrasting Asian rice environments, including the ability to dynamically model salinity impacts on rice.
- The range of yields resulting from seasonal climate variability is more significant than under projected climate changes to 2030.
- Adaptation options evaluated in the project are likely to compensate for the detrimental effects of average climate impacts by 2030. Note that this project considered incremental climate change, and not extreme events and did not consider impacts beyond 2030.
- For greater relevance and uptake, adaptation practices need to address multiple objectives e.g. yield, labour and risk reduction.
- A toolkit of management options can help farmers and extensionists better manage climate variability by allowing them to respond flexibly to the progress of a particular season.
- Developing community capacity to relate weather observations to farming decisions (e.g. with rainfall visualisers and agro-advisories) is important and relatively easy to implement.
- Impredicative Loop Analysis, with a livelisystems foundation is a promising policy and planning tool that integrates social and biophysical aspects of climate adaptation.
- Sustainability polygons are useful visual representations for a range of purposes, including relative environmental effect, potential for maladaptation, the degree to which a practice is “Climate Smart” and a measure of adoption risk.

These operational learnings feed directly into the five principles as I have outlined in the summary of insights below. In addition, the research learnings in the second list

show a highly adaptive approach to the research, with different lines of inquiry and findings emerging in the different country contexts.

Summary and insights from Case Study 3

The findings from this case study provided insights and learnings and a proof of concept for all five of the principles I propose as a uniting transdisciplinary methodology. Based on this, I present a detailed analysis of the data from Case Study 3 using the example tools/frameworks that I outline in Chapter 6. The following summary in the remainder of this chapter is a summary of the key insights and learnings.

Principle 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity.

This project was also highly complex, and the lengthy debate about inclusions and exclusions in this project is a good illustration of this principle, and highlights the need for a pattern set and process to negotiate the complexity. This principle is investigated in detail through the findings and analysis in Chapter 8.

Principle 2: Co-production of knowledge across the boundaries of knowledge cultures and worldviews requires an inclusive shared language for human and social enquiry.

This case study illustrates the challenges of co-production where multiple world-views and approaches to knowledge are brought together. This includes significant cultural differences and language barriers, as well as the differences in disciplinary conceptions of the problem. I explore this in more detail in Chapter 9.

Principle 3: Working constructively with tension is a catalyst and foundation for transformational learning and change.

The narrative in this chapter highlights sources of tension and potential conflict, including the difficulties of working at multiple scales, etc. I explore this in more detail in Chapter 10.

Principle 4: An iterative or recursive research inquiry process is essential for transformational learning, and for theory and practice to inform each other.

The mid-term review and subsequent planning meetings highlighted the importance of regular review of activities and planning and an iterative process, but also how challenging it is to create the environment for this to happen. This is particularly in the context of tight timelines, tight budgets and the tyranny of distance (given there were five countries involved). I discuss this in more depth in Chapter 12.

Principle 5: Reflection and reflexivity (both habitual and systemic) are essential to enable the researcher to constructively capture transformational knowledge co-production.

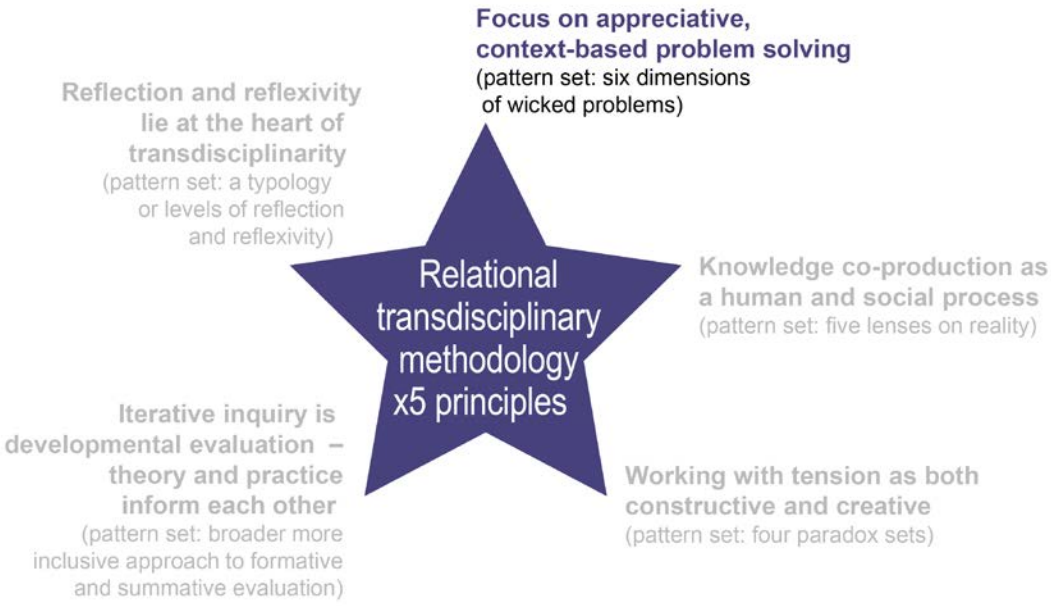
I observed (or was told about) numerous incidents of reflective practice (and the transformational outcomes of these) in this project. For example, the project leader himself talked about his highly reflexive approach, and the transformational journey he undertook during the course of this project. I report on this in more detail in Chapter 12.

Summary

This narrative forms the basis for the analysis of findings presented in the following chapters. Apart from informing the emergence of the five principles for a transdisciplinary methodology, the contrast between the narratives should also be commented on. The narrative from Case Study 3 is far more vivid and detailed than the accounts from case studies 1 and 2, and demonstrates my own more intense personal involvement and engagement.

The atmosphere and ethic of this project was quite different to the other two case studies in that there was much more open debate and discussion, and the team members appeared very comfortable with each other and willing and able to enter into constructive conflict amongst themselves. I suggest that this is due at least in part to the more advanced stage of this project, which was in its third year when I joined the team. I also attribute this to the kind of leadership style, which was very open and inclusive, and comfortable with, different views and approaches as well as constructive conflict. I discuss this further in Chapter 12.

CHAPTER 8
APPRECIATIVE CONTEXT-BASED PROBLEM FRAMING



A detailed analysis based on Case Study 3

In the previous chapter, I outlined the iterative process of progressive case study data collection and analysis alongside literature review and theory adaptation, which led to the proposed methodology in five principles for transdisciplinary research practice. In this chapter (and the four following chapters), I test the five principles and their associated pattern sets through a detailed analysis of data from Case Study 3.

Setting the scene: testing the pattern set for the first principle

In this chapter, I focus on a detailed analysis of Case Study 3, based on the first principle.

> *Principle number 1: A collective, inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity.*

I test the pattern set I have associated with this principle (as outlined in Chapter 6), which is an adaptation of Ashhurst's six, wicked problem dimensions, as a means to explore context-based problem definition in Case Study 3.

In Chapter 3, Weaver's systems of organised complexity are self-organising systems with emerging characteristics and relationships, the source of new possibilities and dynamics, and a source of change and novel solutions. In a system of organised complexity, the problems are likely to be wicked. These are problems that defy complete definition, have no final solution, where any solution creates new problems and issues, and all solutions are partial and the best that can be done at the time.

Nailing down the problem statement is likely to be fraught with difficulty, and the conventional wisdom in dealing with this is to narrow the focus and pick a small number of variables thus risking oversimplification. However, as I outline in Chapter 3, this can also narrow the possibilities for novel solutions and new thinking, and can increase the risk of failure. Also, the conception of the problem will vary vastly between different disciplinary and non-disciplinary participants (where none of these perspectives is necessarily wrong). Ramalingam (2014) describes wicked problems as being difficult to define, where many potential explanations exist, there are multiple views and multiple potential solutions. In addition, it is nearly impossible to "stand outside" the problem and claim objectivity, as the researcher and the research team are by definition part of the context and exerting an influence on it by simply being there and asking questions.

In this chapter, I firstly investigate the complexity of the research context for Case Study 3, and secondly, I bring together the different perspectives of the researchers to build a more systemic picture of the situation using Ashhurst's (2014) modified six wicked problem dimensions as an heuristic or analytical tool for transdisciplinary research teams. The six experiential dimensions (as previously outlined in Chapter 3) are instability, ambiguity, intractability, confounding factors, complexity and diversity. The dimensions overlap and a particular problem attribute can be grouped in more than one of these dimensions. This framework provides a way to organise this information into patterns (but not discrete entities). This aligns with Alexander's idea of the pattern language.

In reporting on the findings in this chapter, I have described each wicked problem dimension separately. Within each dimension, I have first described my interpretation of the concepts captured by each dimension (Concept), followed by a summary of the findings that I have coded according to each dimension (Findings) and lastly my interpretation (Interpretation).

Instability dimension

Concept

The instability dimension highlights the dynamic nature of wicked problems, and that these problems are unstable and constantly evolving from a number of perspectives. It encompasses the degree of change as well as different rates of change in different parts of the system. It covers a number of different kinds of change, including changes in thinking, physical and social situations, as well as the unpredictable nature of complex systems.

Findings

Household typologies and instability

A key component of the project was developing a set of household typologies to try to capture some of the diversity within farming systems and households. CS3A said "*What has clearly come out of the work in both Laos and Cambodia and India, is that farming and diversity of income streams have changed dramatically in these communities. So that they are no longer full-time farmers, they are looking at external income generation. So I think that is very important, that the kind of smallholder farmer is changing very rapidly, they are becoming a lot more diverse in their income generating schemes.*" This is a good example of instability in a research situation, where studying households according to the sustainable livelihoods framework requires careful thought in that the livelihood profile at the time of the study can have changed completely (and rapidly) through the life of the project (through both internal and external factors).

The wider team was well aware of this − and reflected this in their discussions with me, and in their methodology and approach, which changed as their learning progressed. CS3C said, "*I suddenly realised how narrow the adaptive capacity assessment stuff was, and the livelihood stuff was, because it's static. It doesn't give you trajectories and*

… it's not straightforward in how you scale it. … So our experience with the types has sort of led to this realisation that households are dynamic and the types don't necessarily reflect that … but also urbanisation, migration, all these other development trajectories that are likely to override or derail if you just focus on climate."

CS3D pointed out the importance of history and what has come before, "*that's where you need to look at 30 years of history to be confident that you're not leading people up the wrong path*."

He also highlighted that the farmers he was working with were dealing with a very rapid rate of change. "*In a way, there's been a bit of a transition from traditional ways of farming to a kind of farming that the industrial revolution has brought along. There's a very rapid change. For example, when this project started, there was almost no mechanisation on these farms. Now I think maybe 80% of rice harvest is mechanised*."

The rapid shift to mechanisation was talked about a great deal in the project. CS3P: "… *we've seen it already in the two or three years we've been there, mechanisation of, or the use of two-wheel tractors as labour gets harder to find, they're looking for ways of improving things … or speeding up things like planting and harvesting. So I think you are going to see increases in harvester numbers*."

Climate change and instability

One of the key issues highlighted by CS3B was the goal of planning for climate adaptation for 2030 or 2050. "*With rapid change already happening, so much can change in that time and no one has any definitive idea about what the farming systems and landscape will look like, nor what other social and environmental change may happen in such a complex system*."

More importantly, many participants noted that farmers were not concerned with what might happen in 30, 40 years or at the end of the century, but were focused on surviving and flourishing now. CS3B: "'*Well have you any idea of what the future farming landscape will be in 2030, 2050 for which you want to be effectively adapting?' and the answer was 'no' … just dealing with climate variability is the best way to try and build capacity for any climate change.*"

CS3F said, "*You know, there is a view of adaptation to climate change, as a sort of transformational change. I don't think in any of the countries here we are looking at transformational change. … I think most of us are doing things to reduce risk of catastrophic change, catastrophic damage to crops or just give them a couple more strings to the bow in terms of their livelihoods and adaptability*."

Project team staffing and instability – an Achilles heel

CS3B talked about the problem of staff movement and the rapidity with which people change jobs. "*I mean people move, I think that's your biggest challenge in any of these projects. The main effect is, you could say a loss of continuity in the project, in having to go back and start a learning process … which is time consuming and has implications. These are internal [organisational] issues. So, yeah, everyone is moving."*

The project leader reported on the challenge of staff "churn", particularly around the leadership team, and the need for replacements as members of his leadership team (deputy project leader and the project coordinator) moved on to other jobs.

He said, "*So when X left, I said, okay, I've got Y. When Y left, I said, 'I've got a problem'. And I am frantically trying to get people into a position that they can continue the project without me. But right now, with the current complement of staff, I don't have people yet ready to do it on their own.*"

He also reflected on the need for what he called the integration skill set and commented that there seemed to be a limited pool of people around who have these skills and abilities, and that at that time, there was really no one who could take on his role if he was no longer able to continue. "*And that is the Achilles Heel of this project, that it is still too dependent on [specific people]*."

This instability of staffing applied across all of the country partners. Many of the participants talked about the multiple changes in staffing in the teams they worked with across countries. CS3F said, *"So it happens fairly often in [country], they start out projects, sort of roll out the 'A' team. … And bit-by-bit they got hooked up in other projects. … Once the project was up and running, then they would say, 'Ah, we have the 'B' team. Yeah, so you have to go through all the [training and team building] again … And we've actually got the 'C' team as well'."*

This project experienced frequent changes in personnel both at the funding agency level (up to four program managers even before the second half of the project), and within the project team itself.

Timing is everything

One of the less visible elements of instability for the research team was the shifts in policy which were happening rapidly in the background. At the start of the project, climate change adaptation and mitigation were top priority policy issues for Australia. By the time the project was reaching its conclusion, climate change had become virtually unmentionable within government agencies in Australia. This had significant implications for potential follow-on work and research implementation. It also demonstrates the stark difference between policy (or rather political) timeframes and research life cycles.

CS3D talked about the importance of timing with regard to focusing on issues like climate change. *"It was seen that [country name omitted] wasn't ready for climate change to be the focus of a project when I started [my project] not because of the project … but events around the world [meant] that [the] emphasis changed so it became open to that focus. It just happened … the world [focus] around climate change."*

Interpretation

The findings in the previous section create a picture of a dynamic, rapidly changing context, including rapid changes in the farming communities and farm households livelihoods being studied, against a background of rapid regional change. These factors included increasing mechanisation and the rapidly escalating cost and scarcity of labour. Sitting behind this are the various forces associated with globalisation; for example, the rapid urbanisation of populations in many parts of the developing (and developed) world, and the growing connectedness. Ramalingam talks about the increasing risks associated with greater connectedness, for example, vulnerability to economic downturns and shocks (2014). Not only did the researchers need to observe and understand this instability, they needed to see this as integral to the research context and problem.

This rapid change is reflected in the dynamic nature of the project team, characterised by the rapid turnover of staff, changes in institutional environment and wider policy changes and adjustments by the funding agencies. Even more importantly, it highlights the need to see change within the research team and associated institutions as part of the research context, rather than an external (or non-project) factor. The extension of this is that the researchers themselves, the team they are part of, and the institutions they are associated with, are an integral part of the research landscape, rather than sitting outside of the research situation and looking in.

While many of the researchers spoke to me about the issue of instability and unpredictability and their approaches to this in the interview sessions and amongst themselves, this was not explicit in the project proposal or design, though these issues were reported somewhat marginally in the progress reports. Given that capacity building and learning and development were objectives of the project, I suggest that it would have been helpful to be more inclusive of these contextual issues, such as rapid changes in personnel, for more comprehensive and informative problem framing.

The extension of this is the idea that no researcher can be truly objective or stand outside the context they are researching. While this is accepted by many of the more qualitative social science disciplines, striving for objectivity is still a key goal for most aspects of quantitative research (post-positivist).

The findings demonstrate a degree of researcher adaptability to these sources of instability. In addition, and importantly, a number of the researchers identified some of the instability elements as opportunities for solutions and improvements. An example of this is the focus on climate variability. Rather than trying to develop adaptation options for a distant and unpredictable future, the project was instead adjusted to focus on identifying adaptations and coping mechanisms for short-term variability (and unpredictability) in climate and a range of other non-climate social, economic and physical factors. A second example is the gradual evolution of the household typology approach towards a livelihoods trajectory. In conclusion, the instability dimension illustrates the changing nature of the context and the need to regularly re-evaluate the research problem and context.

Ambiguity dimension

Concept

Ambiguity is taken to mean vagueness, fuzziness of meaning, authority, technology, goals or action. Ambiguity also covers multiple, indistinct, incoherent or fragmented meanings. This can include different interpretations of data, and lack of or uncertain data. It includes contradictory underlying cultural and/or tacit meanings, and distributed or unclear responsibility or lines of causality that can lead to a relatively large number of possible actions, approaches or solutions. It can also include an absence of authority. Taken together, this leads to uncertainty and unpredictability. There were a number of instances of this in the data.

Findings

The subject of the project – climate adaptation – was ambiguous in itself. The mid-term review report summed this up very clearly: "*Notions of adaptation, climate change and farming systems are elastic terms that can be stretched to include almost anything*." And, "*There is widespread consensus per the fact that the process of adaptation is ill-understood.*"

In particular, the researchers talked about trying to gain a shared understanding of climate adaptation with the farmers. CS3D: "*It was actually very difficult at first to I guess elicit from farmers what, how they were already adapting and that's sort of taken us a long time, maybe we're still learning about that. So part of that is I guess just the difficulty of communicating in our cross languages, but also I suppose their understanding of what we mean by that evolves …*"

CS3D said, "*The [farmers] had a very explicit understanding that climate was variable, and in what way it could vary from year to year. But when I asked the [farmers] question, 'So what do you do different in different seasons?' … the answer was unequivocally 'we do the same thing every year' … It's totally untrue, and it's taking a long time I guess to work out what they do differently. … There isn't a shared language or a shared knowledge about it.*"

CS3F: "*And everyone's recognised the implicit need to have people in there who can*

delve into what are the real constraints these villagers and farmers have in terms of what they can do to adapt. Otherwise, if you just have a bunch of farming systems modellers … I can easily see you coming up with things that look great on the computer model or journal page, but are [not meeting the needs of the farmers]."

These two perspectives highlight the difficulties of creating shared meaning between different languages and cultures, and provide some examples of the potential misunderstandings and ambiguities that can result.

Another example of ambiguity was the discussion about feminisation of agriculture, and the lack of clarity about what this meant. CS3L: *"… you feel there is a feminisation of agriculture, but not in the traditional sense where more women are getting into the formal agricultural activities. … The new generations of women, the daughters and the daughters-in-law, they are less likely to participate in agricultural work. But I was uncomfortable. I kept telling [the project team] to go slow [in characterising this process], because we have the census coming up which will give us a real picture of women heading households.*"

In addition to the issue of feminisation, there was some ambiguity or fuzziness in relation to the household typologies. Not only did different team members give a different account of what they meant and how they were being used in the research, the reviewers themselves seemed unclear. The review report states, "*The project has developed a typology of households and attempts to link it to appropriate adaptation options. The typology has retained three key characteristics of households: (1) access to land, (2) access to water, (3) options for labour and remittances, (4) castes and status (in South Asia). The household research may prove useful in the formulation of policy recommendations but at this stage, the typology is limited in scope and does not do justice to the amount of data collected by the project team.*"

Rather than seeing this as a criticism of the approach or results, I take this to be evidence of the confusion around the typologies and what they mean and a direct result of the complexity, multiplicity and ambiguity of rural households in general – yet another challenge for the project team.

The review team's report goes on to say, "… *the overall overarching conceptual*

framework could be further clarified." In the report, they question the provenance of the framework, not seeming to realise that it is based on the Sustainable Livelihood Framework (SLF), nor does it appear to be clear that the particular four household characteristics were used to align with the kind of data which the project team anticipated would be available at the national government and policy level.

This is clear from their statement, "*It is not clear how 'spatial transferability' can actually be implemented given the potentially broad range of social, economic and biophysical conditions that are present in each of the four countries*."

The review team also suggested the use of glossaries and outlined some of the different language usage (within English alone) around climate and weather terminology to avoid confusion and misunderstanding and reduce ambiguity. It was unclear how this would help, given the sheer diversity of meaning and perspectives representing in the project team and wider stakeholder group.

The whole process of the project generated ambiguity and uncertainty. CS3K: "*It is very difficult to operate in adaptive management because all of us like certainty. So you start with your project and think, ok, I'm going to do these three things. So, come hell or high water almost, people pursue that angle, because people feel so constrained by what is written down.*"

This feeling of constraint is supported by the project documentation, which provides detailed log frames, milestones and deliverables which committed team members to pre-set outputs and outcomes. However, the project leader was quite explicit in saying that these outputs and outcomes could be, and were, reviewed and amended.

In their report, the review team suggested: "*Ideally, any project member ought to be able to explain with clarity, in a few sentences, what the project is about. A supporting diagram should be self-explanatory without the need for complex explanations. The take home message must be understood by people from different social and economic backgrounds, and who may have limited understanding of climate change*."

This is an ambitious ask in a highly complex project, and requires a very high level of competency in communicating complex messages to diverse audiences. Part of the

purpose of using the wicked problem framework is to investigate a useful tool for doing just this.

Interpretation

Ambiguity in this case study project seemed to emerge at least in part as a result of language, cultural and disciplinary differences, given the sheer diversity of project team members and wider participants, but also as a result of the complexity of the problem and the subject matter (e.g. climate adaptation, climate change, resilience etc.). The wicked problem framework may be a useful way to identify some of these ambiguities and make them explicit.

The suggestion to prepare glossaries is a sound one, and could help to clarify some of the ambiguity. However, there is a risk of reducing the range of meanings and interpretations and thus losing some of the opportunities for alternative solutions and richness of meaning inherent in such a diverse group.

Creating shared meanings was an issue in all three of the case studies. In Case Study 2, there was considerable ambiguity in relation to the technical definitions used by the different disciplines to describe similar things. For example, a group of veterinary scientists described chicken meat as “high quality protein”, while the public health researchers called it “bioavailable protein”. While this appears to be a minor issue, it was of great significance in the research process as each meaning contains background knowledge and assumptions. An attempt to negotiate a unified meaning was unsuccessful and probably unhelpful, as the diversity of meaning was important for retaining the depth of knowledge and perspectives.

Intractability

Concept

Intractability generally refers to the (in)flexibility of frame positions, institutional and organisational or socio-political structures, and resistance or otherwise to different ways of knowing or doing. For example, it may be a measure of participants’ willingness or ability to change their views or work within a context of diverging views. The flip side of this is tractability, which indicates an ability to cope with, and engage with, change,

uncertainty and unknowns. This dimension is generally people-centric, though can also be used to describe the nature of problems more generally. In particular, this dimension captures the idea of world-views, paradigms and cognitive frames. So intractability can be a measure of individuals' (and groups') ability to make paradigm shifts or adjust cognitive frames in an environment of uncertainty and ambiguity.

Findings

Tractability or intractability within the project team

Intractability has its flip side – tractability. Both were expressed within (and about) the project team and its members.

CS3E talked about the willingness of team members to be flexible and adaptable and accommodate their colleagues: *"I don't think it's been that hard and I think that the reason is that the people on the project team – while some of them may have been sceptical, they were all kind of eager to try and make it work. … When I say sceptical, quite often in any project and any discipline you get the baggage from previous experience.*

"S*o I've been lucky in that I have always worked with the teams where the biophysical scientists have been really open to [social science approaches], but in coming into this project you can sense sometimes that there have been, not everyone's been as lucky as I have and they've had a bad experience with a social scientist and its made them really wary, or they've worked with social scientists that refuse to explain their jargon, or refuse to try and speak a common language."*

I also came across evidence that there was some resistance to and misunderstanding of the different foundations and ways of operating between the social and physical sciences. There were various views on this.

CS3P: *"I think the reason [that the typologies were less successful in x country] was that [the social scientists] were too slow. My view that within six months the agronomists knew enough through sitting down and talking to the farmers what the issues were and what we needed to tackle, but it took the social science group a lot longer than that to come to any conclusions. And we'd still argue that they don't really*

know the system very well, and a lot of that's to do with their naivety. They … know very little about agriculture. … In your semi-structured interviews, unless you know which rabbit hole to continue to follow, because you know there is something down there, if you don't have the expertise or the knowledge [then] you miss out on an awful lot."

CS3G: *"So I think the [biophysical scientists] have an inherent understanding of the socioeconomics … of the landscapes in which they do APSIM modelling, it's just that they … aren't used to it sort of speaking out loud. So some of the resistance, I think, was just, 'well, this is new and different', rather than 'There's no need for that'. I mean [social scientists] are scientists like everyone else, they're not, you know, airy fairy nutters, they're kind of grounded in reality. … They have areas of research and frameworks, and I suspect, unfairly, have had to prove themselves far more than biophysical scientists have to. So in some ways they are far more rigorous than some of the biophysical scientists. I think … social scientists get a bad rap and so they have to work twice as hard as other people to be in the same place."*

In many ways, the leadership of this project challenged the biophysical science team members (who were used to being the dominant or leading disciplines in projects) right from the start. While the need for various kinds of social science expertise was already understood, initially CS3D said*"… they were sort of add-ons. They weren't legitimately or equally placed.*" The project leader had (unusually) made a social scientist his deputy project leader, rather than taking the *"rubber stamp social scientist"* approach.

This step initially caused quite a stir in the project team, though as the project leader put it, "*it sent a clear signal*" that the project was not a biophysical agricultural project, but at the very least an interdisciplinary one.

CS3L provided an example of tractability in a very positive account of changing thinking in his country team around the introduction of social science and scientists. CS3L: "*Initially, yes, it was difficult, but halfway through, everybody was comfortable. Maybe the way the teams were put together, it also depends on the individuals. It was easier for us to get accustomed to [the mix of disciplines]. For instance, X [researcher] didn't have a clue about [the social science approach]. I'm sure he thought it was useless. [But now] he is recruiting socio-economic people and wants us to train them.*"

Similarly in the group feedback session at the mid-term review, the following comment was made: *"… we started with multi-disciplinary, multi-organisational project with teams that I think in the beginning decided to tolerate each other, have grown through stages to perhaps respect each other and now really appreciate each other. So to me, that's a really outstanding achievement*."

The issue of intractability versus tractability among farmers was also discussed. CS3K: "*If the whole world collapses, [the rice farming household] will still have bags of rice at home that [they] can eat. [They're] not going to starve! These countries are very poor and people are hungry. It's very rational. They grow rice, and culturally, they will grow rice. It's like in Australia you know why a sheep farmer will be a sheep farmer in the next generation. So people will grow rice*." In other words, people have a tendency to "stick to what they know" and also to avoid what they perceive as excessive risk. "Sticking to what you know" is not restricted to a particular knowledge culture, cultural group or set of research participants.

Interpretation

The first aspect of this dimension relates to the willingness of participants to adopt different practices, in this case farmers growing different crops and taking different farming approaches. The inference here is that people prefer to stick with what is familiar and safe, and has much to do with risk management as well as lifestyle and cultural background.

This project team's ability to be tractable (and adaptable) has been a success factor for them. As described above, they had adapted to working and thinking in different ways and spoke of their enjoyment of the process. In particular, they have had to deal with a number of unexpected and previously unknown factors, and (as illustrated in the instability section above) have had to adapt to frequent changes in the project.

The discussion about working with different disciplines (often described as "biophysical" versus "socioeconomic" which are broad groupings in themselves) has some underlying power issues to unpack. Most of the projects funded by this particular funding agency are always led by a "biophysical" scientist, and there appears to be an underlying assumption that social science in its many guises is there in the role of

service provider rather than necessarily to conduct research in their own right.

In this sense, tractability could be described a willingness and ability not only to be open to other ways of knowing, but also a willingness to share power. It also refers to people's willingness or otherwise to implement change.

Confounding factors

Concept

The confounding factor dimension is a measure of the factors which may limit action or alternatives, or which may work against each other. These factors can be political, environmental, chronological, cultural or organisational. It can also include limitations in resources and knowledge and the necessary drivers or incentives for change.

Findings

One of the particular issues in international agricultural research for development is that there are likely to be remote teams, and considerable travel. Many of the participants raised this as a substantial challenge. These statements capture a level of frustration at being able to spend limited time "on the ground" or "in country".

CS3B: "*In [funding agency and research agencies] there is a perception that you can run complex projects from Canberra. It's an absolute disaster, and I mean if there is one thing I would be adamant about is that there is an international research organisation either partnering or leading it. And the reason is, they are on the ground, they can make things happen.*"

The ability to gain an understanding of the local research situation was limited by infrequent visits and limited time. Different participants reflected this in a number of comments. (Group feedback session mid-term review): "*The thing that could be done better in a different project, I think for me, every time I visit [country name]. I learn a lot and I learn so much about different things. And the more time I have to spend in country, the more I can learn … and to have discussions that are much easier to have in person than by email or by Skype.*"

(Group feedback session mid-term review): "*the time [spent by] us Aussies in country*

is too infrequent and not long enough. It was sufficient to make this project successful and achieve its objectives, but it wasn't efficient in terms of the way we did it. And in a future project, I would look at ways of trying to resource some of the Australian partners to be in country for longer periods. … But I feel like suitcase science is a real constraint on a complex project like this."

There were quite a few references to the impact of travelling on the researchers' families. CS3F: "*I actually do enjoy travel, but it's pretty hard on my family.*" For this researcher, there was a constant tug between wanting to be with his family and wanting to spend more time with the project team in country.

Some of the researchers expressed regret that the mid-term review was the first opportunity for them to integrate across the five countries involved. Some of the comments from the group feedback session were as follows:

(Group feedback session): "*In projects I've run in other places, we talked about cross visits. We tend to talk about those in relation to farmers going to another group of farmers to see what they're up to. I reckon we should do this in this project. We should be cross-visiting to other countries because I've learned things here in the last few days that I had no idea were going on in other countries, but which could have been, at least trialled in [my country]*."

The reviewers provided the following feedback: *"… it's a huge endeavour to make things work on a big project like this. … You tend to underestimate the need for communication for clarification, even to go across the hall to your colleague and … say 'Hey what do you mean by this in your email?' And that's something we tend to underestimate and it's very difficult when your partners are in different countries and you don't meet people often enough*."

Available time was also named as a key confounding factor or constraint for the project. The project proposal documents the proportion of researchers' time allocated to the project, which generally ranged between 10% and 40% of their work time, with only the project coordinator allocated at 80%, and the project leader allocated at 40%. Added to this, the project ran for five years, which given the complexity and sheer size of the project was not particularly long. They often had quite a number of additional project

commitments, as well as management, administrative and other organisational roles and tasks demanding their time.

CS3E: *"I'm allocated to this project for a majority of my time, so I have quite a lot of space to work through these issues [of complexity], but a lot of our partners they're so overcommitted. I am probably a bit unusual in that respect."*

CS3G: *"I think the biggest challenge … has been the overcommitment of key colleagues. So they're frantically busy and … it's one of a number of projects, and possibly not even the most important project. So they've got a lot on their plates …"*

Other confounding factors which are discussed in other parts of the findings include lack of gender sensitivity, short timeframes, budget constraints, pre-planned activities and power relations (particularly between dominant and less dominant disciplines, and certainly between researchers and non-researchers).

Interpretation

The "suitcase science" remained an issue, and most respondents agreed that the best solution to this was to be based in, or spend more time in, the project focus country. Added to this the limited time allocation and length of project and this becomes a very challenging situation for such a complex project.

The issue of power imbalance is a subtle one, and is partly documented in the section on intractability. The accounts of CS3P and CS3G in the previous section on intractability also point to a confounding factor. These accounts indicate a lack of understanding of the approaches, knowledge and tools of the social scientists (in this case social anthropologists) but more importantly a lack of willingness to learn and engage, and the suggestion that biophysical knowledge is "better" and more powerful than that of the social sciences. While these are examples of confounding factors, it is by no means a comprehensive list, but provides indicative examples.

Complexity

Concept

Complexity refers to the sheer number of elements, parts, interactions, details, and relationships in the problem system. This dimension can also be a measure of "messiness". Relationships between parts, and between parts and the whole, are generally more salient than the individual parts themselves.

Findings

The researchers in CS3 talked a great deal about issues around complexity, particularly since this project was conceptualised as dealing with complex systems issues. They grappled with the sheer number of elements and intricate details, and with how to take a systemic approach without blowing out the scope of the project.

CS3K summarised the challenge. *"So, … I can see it is a large project, a complex project in that it is cutting across geographies, cultures, and cutting across disciplines – climate science, agronomy, water management, social community and understandings of climate and agronomy, and economics of different systems. And in that sense, it is trying to develop the model of being able to explore those complex interactions. There are many staff associated with it so in that sense also it's a very complex and challenging project*.

"*But you can't put in a project research proposal [for example] that says, 'There are lots of hungry people in eastern India (or wherever) and it is probably to do with land and water. You [need to] spend two million bucks with this team to find out what it is all about.' If you are purist, that's where you would start – but no-one will accept a project proposal like that!"*

CS3C talked about the challenges of the project design, and how this complexity influenced the process and dialogue around the proposal design in the early stages.

CS3C described a meeting with the donor in which there was debate about the scope of the project: *"And we presented [to a meeting of funding agency staff] on the rationale of the project, the methodology … you know, the research strategy and everything, and*

made a very strong case for why we thought you needed a lot of social research to underpin it and why you had to ground adaptation and understanding livelihood strategies, which was obviously far broader than just land and water, or soil, water and crop nutrient management which was the original scope.

"*So there was a strong suggestion that you need to include livestock because it's a key component of resilience in farming systems all around the world. And it's a key way of people adapting to shocks.*

"So we had a long discussion around this. … And in the end the [meeting] was pretty much split down the middle about [the livelihoods approach and livestock inclusion]." In the end, the meeting voted against the inclusion of livestock, and against the livelihoods focus in favour of a rice-based systems approach, which the project design team felt left the complexity poorly acknowledged. (The livestock issue is discussed further in Chapter 10 in relation to parts and wholes.)

Another challenge in the project framing was the issue of differentiating this climate adaptation project from the emergence of a major food security initiative. CS3C said, *"And suddenly it dawned on [the funding body], that what we were proposing to do was pretty much what they wanted to do in their food security project. So the strong focus on participatory on-farm research. That was the common element. And they came back and said, 'Oh sorry you're on the wrong track here. We want you to do something that's more 'climatey'. Where are the climate projections etc.?'"*

This narrative highlights a constant tension between the need for manageable scope and the complexity and multiple elements of the problems they were trying to address. It also highlights the space in which research systems and processes are needed that can address complex and wicked research problems. And that simply restricting the scope is not necessarily the answer, and can be counter to the whole purpose of the project.

The other point that it highlights is the need for a more clearly articulated context and problem focus. Obviously, there is a lot of overlap between food security research and research into climate adaptation – it is impossible to separate the two. Plus participatory on-farm research is an integral part of both activities.

The project leader described his perspective on developing a workable systems

approach, and the battle to stay within budget. *"The resources $x million seems like a lot of money, but how do you match your milestones and everything you promised with the resources you have? In a project of this complexity you could be completely off target. … But we do not have any formal requirements for project leaders to go through [such a level of detailed planning] … I've never … it's never been asked of me."*

There was much discussion about scope during and after the mid-term review. A number of the participants spoke in the group feedback session about the complexity of the project, and that this had been underestimated and had led to some mission creep. For example, in one of the countries, there was an unanticipated large training component around the APSIM modelling. While participants said this was a very positive outcome for that particular country, the training team completed this exercise at the expense of other activities.

The reviewers said, *"There is little doubt in our mind that [funding agency] achieved value for money, indeed a few of the scientists mentioned mission creep whereby this project had taken more resources than they had anticipated. … To summarise on the question of scope: We recognise that this is a difficult task … However, one of the reasons that it is difficult to identify exactly what the project is doing and to have a clear message on this, is the lack of clarity on how the bundle of activities was chosen… Scope is a challenge in a multidisciplinary project covering four countries. Notions of adaptation, climate change and farming systems are elastic terms that can be stretched to include almost anything. The project would gain in clarity if the process leading to the choice of activities included was more explicitly explained."*

Complexity of farming systems

CS3G, who was involved with APSIM modelling, spoke about the complexity of the farming systems they were studying and the multiplicity of factors that could have been included in the modelling and adaptation strategies. CS3G: *"… So we start talking about, 'Tell me about your farming system'. So [from the local agricultural research agencies] they have ideas about the sorts of options to trial on farm and to model, and they're … some of them are agronomically driven and some of them are driven from government, which can be a little frustrating, so we spent a whole season's field trials looking at fertiliser, because there was a big push on from government to increase*

farmers' yields by putting on fertiliser. … So we did all these field trials, farmers don't want to put on any more fertiliser, because it's expensive and there is very little gain for them …"

CS3I: *"… look for me, it was always clear that … climate adaptation is not the number one agenda of farmers, because of the fact that they are already struggling with all sorts of stuff. But on the other hand, climate variability and change affects all the other things that farmers are struggling with. So even if they adapt to other stuff indirectly, it might also be adapting to climate change, or mal-adapting to climate change, whichever way you want to … so you can't disentangle these things*."

The issue of livestock inclusion cropped up here also. CS3P: *"In an ideal world it would've been nice to have animal production in there, but … it would've made a huge project. It would've possibly diverted or distracted attention and interest in particular areas."* This was a difficult exclusion for the researchers, given that most of the farming systems had at least some livestock, these livestock were often a risk mitigation tool, and the keeping of livestock altered the household labour dynamic significantly.

CS3J grappled with ways to pull together the sheer volume of information and how to ensure this was captured and adopted. *"… Potentially at the end, we're going to be left with … a whole sweep of tools, which have been proven but are nowhere near integration point. So what we want to do is then document each one of these really, really well and think about how they can be … adopted so that … hopefully there will be a follow on where hopefully we can get into some integration into some real recipe-based tools."*

Interpretation

The analysis of the complexity dimension gives some insight into the huge challenges of dealing with so many parts, relationships, interactions, and the level of messiness. It also demonstrates the risks of trying to "ring fence" different research activities on the basis of policy direction. Approaching the research from a food security perspective, climate adaptation or livelihood improvement more generally, is a disciplinary "trap" in that the problem definition is defined through a set of disciplines or discourses rather than a tangible "*Lebenswelt*" or life-world problem. This creates challenges and

dilemmas for the researchers, and cannot be solved by the dominant research approach of isolating and excluding variables. Nor can one particular approach or technology suffice as a solution. This highlights the need to take a non-disciplinary, context-based problem approach.

Diversity

Concept

The diversity dimension is a measure of the number and variety of participants in a problem system. This includes variation in versions of reality, worldviews, values and priorities. Social complexity, scale and sociological factors (e.g. age, gender, ethnicity and education) are important here.

Findings

Even from the project proposal the diversity of this project was very clear. It encompassed diversity in nationalities, agricultural regions, disciplinary backgrounds, ethnicity, and institutional backgrounds. And it was very clear to see in the mid-term review workshop, the sheer diversity of people around the table.

This diversity was a huge challenge for the project that was readily acknowledged by the researchers. CS3B: *"You know, I think with the project leader, he has very good diplomacy skills. … He's a very unique project leader, because he has all the attributes that you require for a strong person to lead a very diverse team."*

The project leader talked about the challenge of ensuring sufficient diversity of disciplinary skill sets in the team, and the decision to appoint a social scientist as his deputy. *"And X [researcher] asked, 'Okay. Is this just another rubber stamp social scientist or is this for real?' … And then I went around the team … and got an interesting reaction, "What, a social scientist as Deputy?' But it did rejig the whole project. So then we started to get a better balance of [disciplinary expertise]."*

Diversity in livelihood typology approaches

One of the expectations of the project was that there would be similar approaches across the four countries, to allow for direct comparisons. But CS3C had a different

experience. *"The other thing that I realised was you got to give space. So we came up with a really neat typology methodology, and gave it to our partners and said, 'Go off and do it'. And of course everyone did it differently. … And we let them do it differently. Because partly it was out of pragmatic reasons that the data sources they had, meant you had to go this way, or that their strengths and how they did these things lay there. So we let go a little bit."*

CS3C said, *"I wouldn't argue with you that if we had more time and resources we probably would've done a much better job of figuring out who we really need to partner with in terms of the transdisciplinary thing. But I sort of think, well, there are different pathways. It doesn't really matter which pathway you have as long as you have some viable pathways where you can have a plausible narrative that says, you are likely to have had a contribution to x."*

CS3E was clear about the need to work with, instead of against, diversity. *"So in the first few years … it was very much around developing broad sort of conceptual frameworks and methods to sort of define [each country's] own bit in a way that they wanted to do it but that still allowed for a relatively uniform approach across the four countries. … So the whole premise of the social science component is that a 'one-size fits all' kind of approach misses a lot and so we have these household typologies to look at how adaptive capacity differs and … that different mechanisms or strategies will be required to support households with different needs."*

Cross-cultural differences

Within the research team, differences between the culture, perception and priorities in research and practice emerged across different countries.

CS3D: *"So the agricultural university is our main partner. I used to assume things about what it might mean to be a professor in an agricultural university in [country name] which I've had to modify quite a bit. … So I guess their understanding of what's expected in rigorous science is quite different [to the Australian view]."*

He also talked about the diversity of stakeholders which the team needed to deal with and how the policy aspects of the latter half of the project had greatly increased the range of stakeholders they needed to partner with or consult. *"Engaging with policy is*

more challenging, because we don't have really strong experience in doing that."

CS3D went on to talk about the variety of stakeholders from the village level upwards. *"So you've got the project villages, they've got the villages leaders and local government. … They are important in the village and often the meetings are around them and they put up notices on their boards …"* He went on to describe various provincial and national organisations, providing a picture of a complex and intricate landscape of roles and interactions.

Other differences which researchers commented on included different academic standards and expectations of academics, research methods and approaches, definitions of rigour etc. There were also various differences between the country teams in terms of how they conducted a discussion. For example, the robust, lively and argumentative approach of the Indian team was challenging for some of the other teams from the Mekong region, who were more comfortable with a more low-key consensus-based approach.

CS3F: *"There's a few instances where there's different standards in terms of how [the team members in the partner country] conduct themselves and their experiments and things."*

CS3G said, *"… it's been incredibly challenging and incredibly hard work, you know, just things like, 'Well, it's 12 o'clock' you know, so everyone stops because you have lunch at 12 o'clock, but we haven't finished the meeting. … Just things like that and figuring out that my priorities are not their priorities, and it's offensive of me to assume that they should be. But it's been a great experience."*

Integration

One of the key points of discussion among the team members was about how to integrate the diversity, across cultures, disciplines and organisations.

CS3E: *"The interdisciplinary nature of [the research] is a big one, and I guess there's two sides to that. One side is, you know, working with a team where everybody is interested and engaged and trying to understand what a different discipline is doing, or a different component of the project is doing. … The transaction costs can be pretty*

high but the other side of that is developing frameworks and methods and conceptual stuff that hasn't, like it's all totally new to me …"

CS3E: *"So I remember at the beginning of talking through the engagement process … I for one sort of sat there and just went I am so lost right now, … its really abstract and I don't know how to make it clearer, but … once you stop being afraid of that and you start going 'this is an amazing opportunity' … where we have this opportunity in a room together and talk through these kind of methods where integration is not just you do your bit, we'll do our bit and at the end of the project we will write a report. It's actually we'll work together and make sure … that the frameworks we're using force us to [integrate]."*

Not everyone felt so positive about the integration or saw the potential learnings and opportunities as described in the previous paragraph. CS3F: *"There's been a lot of talk in the project … team about how we integrate. A lot of these discussions, as far as I can see, go round and round in circles. They are not really coming up with anything, and I think they need to say, okay, 'what are you trying to get out of the information and what sort of information do you want to give the people'."*

CS3G emphasised the breadth, diversity and tolerance of the team. *"It's participatory in that there are all sorts of definitions of participation, participatory research, but from the top down, I think this project shows … respect for all the people who are engaged on it."*

There was a lot of comment about cross-country knowledge sharing and learning, and some diversity of opinion about this. Some team members felt that because the different countries had different contexts and issues that there was no real benefit to cross-cultivation. However, many felt strongly that the different country teams could learn a great deal from each other. CS3C did comment that each country team interpreted and implemented the livelihoods analysis differently, which initially worried him, then he saw this as a key part of the diversity of the project, and an adaptive process for each situation.

Interpretation

By allowing (and indeed encouraging) a diversity of approaches, the project developed in interesting, rich and different ways within the various countries. The various respondents were in general very aware that different approaches and outcomes were needed in different situations, rather than a one-size fits all.

There was also a good awareness of the need to go into a new cultural setting prepared to adapt and learn from the local counterparts. The project leader in particular talked about the importance of different pathways and approaches being the remit of transdisciplinarity. In general, this approach was rewarding for this team in terms of new thinking, ideas and approaches, to the extent that many of them would have liked more opportunities for cross-country and cross-disciplinary learning. The respondents highlighted costs of engaging with diversity in terms of levels of uncertainty, and opening up unknown territory as well as the time-intensive nature of these interactions and explorations, in a project where time was always a limitation.

There is a significant challenge in allowing for diversity – it is more time consuming and requires more redundancy and iteration in process and communication, which frustrated some of the participants. It was also a risk for the project leader – with limited timeframes and budgets and the need to commit ahead of time to key deliverables. In addition, it can be challenging for those who are considered experts – from the comfort of expertise, there is then exposure to the discomfort and uncertainty of new knowledge and not knowing. However, many of the researchers saw this diversity as an exciting opportunity to explore new worlds of knowledge.

Summary and implications

This chapter explores the context and the nature of the problem for Case Study 3 using the six dimensions of wicked problems (adapted from Ashhurst, 2014). The analysis shows the large number of sub-problem areas, the varied views on the problem and the diversity of approaches, and highlights the difficulty of clearly identifying problem focus and research questions. It is a means of exploring the “wickidity” of the problem (by which I mean the characterisation of the research problem as a wicked problem).

The problem is clearly wicked as it meets the criteria set out by Rittel and Weber (1973), where there is no definitive formulation, there is no "stopping rule" or end to the problem, there are no true-false/good-bad solutions, no immediate and ultimate test of a solution, every attempt to solve it is significant, there are enumerable possible solutions, each problem is unique and a symptom of another problem, there is no one "correct" cause or link, and there is no ultimate truth.

The analysis also demonstrates that a wicked problem is much more than simply complex. The description of the complexity was only one part of the characterisation of the problem. The use of the dimensions demonstrates a more systematic and inclusive approach to examining the context in order to focus on the problem and shows that the problem cannot be defined independently of the exploration of the context. This is an appreciative process in that it focuses on possibilities and potentials, and does not shut down or exclude conceptions and ideas of both context and problem, but it demonstrates an "opening up" rather than "narrowing down" of the problem framing.

The findings in this chapter reflect a broad range of contextual issues, challenges and opportunities for Case Study 3. The accounts of the many participants I interviewed came together to provide a complex and interesting picture, which would have been difficult to create at a disciplinary or even interdisciplinary level. No one researcher provided all of this detail – only as a collective account is this breadth provided. However, relatively little of this information appeared to be comprehensively captured in the scoping study or the proposal document.

There are two things to note here. Firstly, that I interviewed the project participants approximately half way through the project, so they had had time to develop a deep and detailed knowledge of the project and its context, which suggests that understanding context should not be underestimated, and is an ongoing endeavour. Secondly, I have applied this pattern set (the dimension of wicked problems) retrospectively to the data, and I did not have this pattern set in mind when I conducted interviews and took notes. So while this analysis provides an overview of the case study project context, it still remains to test the use of the pattern set deliberately as part of transdisciplinary project scoping more generally to develop a more comprehensive picture. I suggest it would also provide the researchers with a clearer picture of the variation and diversity of problem conceptions among the group. Extending this process to non-research

participants is crucial as part of problem framing.

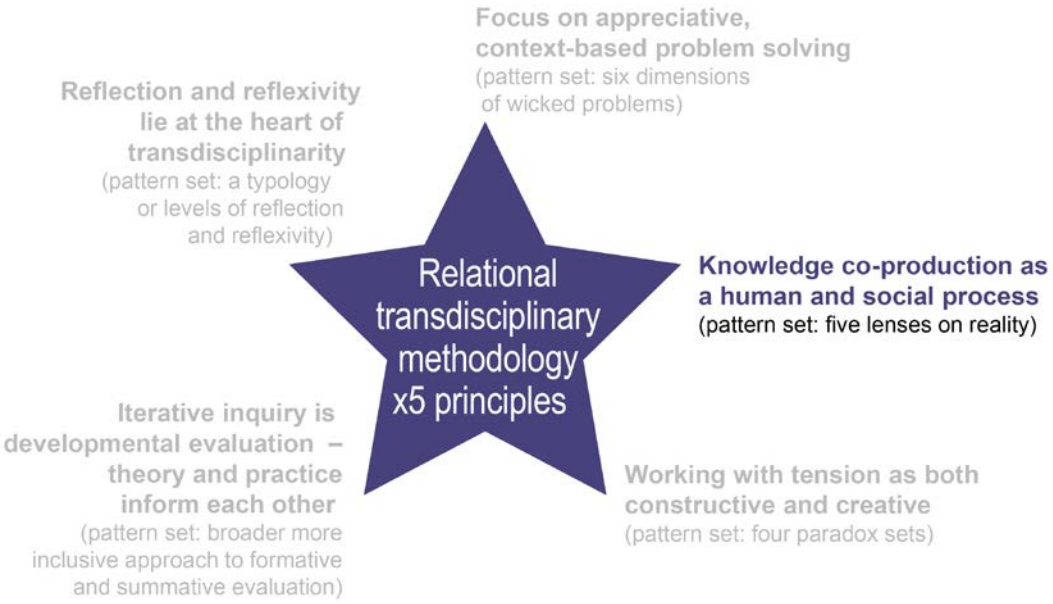
I propose that this pattern set (the dimensions of wicked problems) could be used as a heuristic to create a more comprehensive and collective picture of the context for project scoping.

The point of this particular pattern set is to provide a provisional tool for enacting the first principle: *A collective inclusive approach to appreciative, context-based problem framing is needed to embrace the richness of complexity*. The findings and analysis in this chapter reinforce this principle, demonstrating not only the complexity and wickidity of the context, but the importance of an inclusive approach to understanding the context before formulating the research problem and research questions. Furthermore, I suggest an appreciative approach, as it implies an open and judgment-free approach, which is needed to create the synergies between the different kinds of knowledge and expertise that have been brought together in this project.

Not only does this chapter provide an insight into the complexity and wickidity of the problems that the researchers were tackling, it clearly places the problems of doing the research alongside the research subject itself, so that the context is not just about understanding the identified research problem in situ, but also about understanding some of the challenges of doing transdisciplinary research in this situation. For an effective transdisciplinary project, the context of the research itself and the context of doing the research need to be considered together, and many of the implementation and research practice challenges are not easily separated into doing the research or the research subject matter itself.

One of the very important potential benefits of this is to create visibility for donors of the context and complexity of the research subject and the process challenges. More importantly, this is likely to enhance the researchers' and donors' ability to learn from these challenges and come up with better design and practice approaches. I discuss this further in the conclusions.

CHAPTER 9
KNOWLEDGE CO-PRODUCTION AS A HUMAN AND SOCIAL INQUIRY PROCESS



The Case Study 3 project team was comprised of a wide range of participants from across and beyond disciplines, and across cultures, organisations and social groupings. Integration was an agreed goal for them, and one of the reasons for seeking my involvement was to assist them to evaluate their success in integration and to reflect on the process.

In this section, I have applied the second principle for transdisciplinary practice (outlined in chapter 6) which is that a research team needs a way to bring together their own and non-researcher participants' knowledge, experience and ideas for the inquiry process, and to create synergies between the differences. I have applied the five doorways to human understanding (derived from Brown and Harris' (2014) seven ways of knowing) to explore the perspectives, experience and ideas of the project participants within the inquiry process of the case study project, and to test the five doorways as a potential tool for future transdisciplinary project teams.

These five ways of knowing (physical, social, ethical, aesthetic and sympathetic) weave and link into each other through the process of human thought which can be described as multiple doorways to understanding (Hocking et al., 2015) or as a series of lenses. While all humans have access to all seven, according to Brown and Harris, each of us tend to favour one or more of these ways. These doorways are also intended to provide a means to promote shared, social construction of knowledge.

I did not structure the interviews according to these questions, nor was I intending to apply them at the time of data collection, so the respondents would have had no indication that this was one of the analytical frameworks I would be using. The analysis looks at the evidence of each of the five doorways to explore the invisible, the unobserved and the tacit in the questions the researchers asked themselves and others and the evidence they provided. The analysis also tests the potential usefulness of exploring these ways of thinking in a transdisciplinary study to create common threads and connections without resorting to consensus, or allowing one discipline or world view to dominate.

This analysis illustrates some of the underlying issues of disciplinary or specialised thinking. In this case, I assert that the specialised ways of thinking (the disciplines employed in the research) are often not able to surface or make visible some of the really critical issues in the wicked problem inquiry context. While the components of disciplinary (and non-disciplinary) thinking are crucial to this and other studies, the disciplinary "tacit agreement not to ask certain questions" and the tacit assumptions (Giampietro, 2001, p. 480) and risk of invisibility through the abstractions and assumptions of a discipline (Max-Neef, 1992, p. 34) have had consequences here in the omission and overlooking of key challenges and opportunities around the human aspects of research uptake and engagement for development and social change.

Figure 6: Five doorways to understanding the world

Ethical doorway to understanding

The ethical doorway or lens includes ideals, principles, aims and standards of good and bad. This domain of human understanding underpins our social networks, informing social rules and standards and including concepts such as honesty, justice, equity, dignity and self-determination. It is an examination of the principles and ways in which humans relate to each other (Berlin, 2000, p. 1). I have discussed this particular doorway first, as it is so pivotal to the discussion about policy engagement which was a priority outcome for all three case studies.

The ethical way of knowing came up very frequently through tacit inclusion in the discussion (it was never named as an ethical viewpoint or necessarily as part of the research inquiry process). One of the key examples was the issue of policies, beliefs and priorities around rice-based systems and rice growing and adaptation. CS3L talked about the mindsets and assumptions of farmers he worked with around rice production and subsistence. He compares the aims and values of the subsistence rice farmers. "*The subsistence mind is there … everybody wants to have his own [rice]. At the micro-level,*

the farmer thinks, 'my household needs, I should grow my own paddy, so that at least they have rice if all else fails'."

From an ethical perspective, the smallholder farmers grow enough rice to feed their families, as an insurance against empty bellies and hunger through the year, but the national policy (according to the participants and also reflecting an ethical standpoint) reflected quite a different perspective. "*[Rice growing] is a national priority as well. Food security for the sake of self-sufficiency.*" CS3L is talking here about the policy of his (and other) national governments to ensure that there is at least a small surplus of rice grown each year and preferably enough for export. A further example is the double rice cropping areas allocated through national agricultural policy (particularly in Lao PDR) – requiring that certain areas grow a second crop of rice. Despite much effort on behalf of the project team to find ways to grow a second rain-fed wet season crop, many of the farmers were not willing to plant a second crop. As one of the participants explained to me, the profit margins for rice growing were very small, and the cost, effort and risk of growing a second crop was often not regarded as worthwhile. Various presentations at the mid-term and final review meetings demonstrated that off-farm income was an increasingly dominant portion of household finances and that in many cases, off-farm income took priority.

CS3N described some of the drivers and processes in the rice system in India and why it continues to be grown so widely. "*Rice is crop, we call it the lazy man's crop. Because all you have to do is plant it … then harvest it. The other crops require work. That is one of the reasons [that rice is such a popular and predominant crop]. Another reason is food security … and thirdly MSP, minimum support prices [for rice]. They can sell at a given price. But because of the drought during the last few years, people are switching to other crops. Even in our state, cotton areas have risen like anything in the last two years, even sacrificing rice areas.*"

"*But rice again, … they go for rice cultivation because they get water and all they pay very little. But the other farmers invest a lot in getting the pumps, digging the well, purchasing the pump, operating gate. Rice farmer gets free water. In that way, rice has some kind of security. It is not a gamble, whereas with commercial crops it's a gamble.*"

While incentives such as price support and cheap water worked well in some areas,

other policy directions highlighted a disconnect between national policy and the reality on the ground. CS3G (and others) spoke about this, *"… there was a big push from the government to increase farmers' yields by putting on [more] fertiliser, so [national agency] would have been told, 'You've got to encourage farmers to put on more fertiliser'. So we did all these field trials, farmers don't want to put on any more fertiliser because it's expensive and there's very little gain for them."*

There was much discussion in the Indian team about cropping choices, particularly between rice and cotton. However, the same discussion (sans cotton) applied to the wider suite of countries, though in most cases without price support systems, or cheap or free water. On one hand, rice is about survival. Every household (and this applies more generally for subsistence and smallholder farming) wants to have enough rice to ensure full bellies for the family. This is very often in the face of much higher cash returns and lower risk from crops like vegetables and higher cash returns from crops like cotton. This reflects their principles and aims and is a primarily ethical way of thinking (according to the framework I have used), though there are also strong elements of the other ways of knowing entwined in this (for example the social and physical).

For example, two participants provided two different perspectives on this, highlighting the diversity of aims and values among the farming households studied. CS3P says, "*[Vegetables] are worth a fortune whereas rice is worth diddely squat. It's all about food security, if they really wanted to make money they would grow vegetables*." CS3N: "*Farmers are however inclined towards cotton cultivation, they are sure for getting almost ten to twelve thousand [rupees] after spending maybe five thousand*." In these two examples, the priorities, goals and ideals differed and motivations varied.

All of this highlights the different ethical standpoints around food security, (as well as rice growing and rural households more generally) and the multiple meanings of the term. It also highlights that food security is often tacitly assessed through the ethical way of knowing. For example CS3P made two observations relating to the rationale behind national food security policies: "*If you've got people with bellies full of rice, you've got less chance of a revolution probably*", and "*It's national pride where they've got to have their own [rice] varieties and be seen to be self-sufficient*". He added that this was very much about agency and being able to make their own choices about

varieties grown and the systems used, rather than being dependent on neighbouring countries or trading partners.

CS3P also talks about two levels of discussion around food security, including domestic production and meeting local demand, the push for rice exports and that the drivers and expectations around these are not necessarily economic – the drivers are far more complex and were often difficult for the researchers to fathom. CS3P goes on to add, "*You will never change the people from growing rice, but [there are] some other interventions that might add extra value to the system*."

In addition, a number of the project team agreed that the important task of policy engagement and dialogue had been (in some instances) left until too late in the project. The consequence of this was a less than optimal approach to policy engagement and uptake, and there was much discussion amongst the participants about how this could be improved at such a late stage of the project.

The insights from the above analysis could have been included more formally in the project. A more explicit exploration and discussion of the various aspects of the ethical doorway to knowing could have potentially created an earlier focus on policy framings, and some of the differences between the ideals, principles, and aims of different stakeholders could have helped to focus inquiry approaches in this area.

Aesthetic doorway to understanding

The aesthetic doorway or lens to understanding includes a broad interpretation of sensory perception that goes beyond beauty, desire, visions, concepts of beauty and ugliness (Hocking et al., 2015)[3]. This is the lens or set of questions that goes to the heart of human creativity and is a "springboard" for new thinking. Hocking et al. sum up the design process as working "with people's aesthetic literacy in order to construct understandable objects, structures or spaces that people can interact, engage and respond to in relatively predictable ways" (2015, p. 7). This way of thinking is about the sensory and while it is often equated with art, everyday aesthetics is important for human well-being (Melchionne, 2014). While I expected the aesthetic way of understanding to be mostly tacit in the discussions, it cropped up repeatedly in the interviews and discussions.

The concept of "good science" came up in discussion with a number of the participants, and in workshops and meetings as well. Australian scientist CS3D reflected that his idea of "good science" differed from that of his Indian colleagues: *"What it takes to do good science as I and as Western scientists [do], but in the [Indian] system, there are other ways people can do well …and they don't have to do with [our concept of] good science."* At the same time, CS3D said that he felt one of the big achievements of the project was instilling pride in the ability to do "good science" amongst the Indian scientists. However, CS3D did not go on to explain what he regarded as good science or how his conception of good science differed from those of his Indian colleagues.

There is no clear, unambiguous measure or definition for "good" science here. While universities and other research institutes are currently trying to quantify "good" science through publication counts and H-factors, this is clearly a very limited measure, and I argue that there is a strong tacit or undocumented subjective and aesthetic sense of what is good science among researchers or what Melchionne would describe as aesthetic practice, which results in particular forms of satisfaction or well-being, and hopefully good outcomes for beneficiaries of the research.

The idea of satisfaction or well-being was a common theme in the interviews with the CS3 scientists. Many of them expressed their enjoyment and satisfaction with their work as researchers and being involved with a "good" research project and with particular approaches and outcomes. CS3I talked about "*all of these Australians loving going into the fields and not worrying about whether it's too hot, or whether you have to sleep in a shack for a night or two*" shows a picture of the Australian scientists doing what they love – what they get aesthetic pleasure and a sense of well-being from, including spending time with farmers and being out in the field.

Their appreciation for the environments they worked in stood out too, as in the following discussion on soils in Svay Rieng in southern Cambodia that I had with CS3P.

Me: "*Gosh it looks dry.*"

CS3P: *"Yeah. It's not beautiful."*

Me: "*No, it's not. And the soil …"*

CS3P: *"Well, you come from the Darling Downs!"*

Me: *"Hey! Yeah."*

CS3P: *"Now THAT's soil."*

CS3D, a primarily biophysical scientist, made frequent references to the aesthetic domain of human understanding. He described to me the *"beauty of strategic irrigation"* when we were discussing the field trials. He also placed an aesthetic value on statistical analysis, for example describing a particular analysis as *"statistically better … right across the whole probability scale."* He even put an aesthetic value on successful field trials: *"And the real beauty is it just guarantees you're not going to have a failure."* This and other discussions were not restricted to an objective account of data and results. I suggest that it is more akin to what I would call the creative or intuitive leap – a sensory response related to recognition of familiar or pleasing patterns, and which is at the core of abductive reasoning and innovation, and is inherently non-linear. I see this as an important part of the process of inquiry in this project.

As a climate adaptation project, there was a great deal of discussion about seasonal conditions, weather and climate. CS3D talked about his interaction with the farmer groups and their experience of seasonal conditions. *"They described the season as being a wet season. In fact, it had been absolutely dead-on average season but the rain was very nicely distributed through the season and so they experienced it as a good season*." He said he had been thinking in terms of millimetres of rainfall over the season, whereas the farmers' primary perspective and experience of the season was how the rainfall was distributed which was ideal for optimising crop growth.

Underlying the discussion of optimising crop growth, rice variety selection and alternative crops, were the highly specialised rice preferences and cultural practices in different countries and even different provinces. For example, the Laotians have a particular preference for a kind of glutinous or sticky rice, and some of the rice producers in eastern Cambodia were producing rice for the Vietnamese table, which they would not even consider eating themselves. While dietary preferences are a part of cultural norms and expectations, there is a strong aesthetic preference here too. A meal without sticky (or glutinous) rice is not a meal for a Laotian, and for most of the countries a meal without rice in general is not a proper meal. While this is not a new

concept, a more explicit and systemic understanding and expression of such aesthetic preferences would be useful in the inquiry space in such projects.

Social doorway to understanding

The example of rice growing and rice consumption preferences also has a strong linkage to the social doorway to understanding. This doorway covers the language, images, narratives, myths, symbols, behaviours and beliefs of particular social groups. In this case, there were distinct ways of knowing and understanding for each of the cultural groups between the different participating countries, and further social groups with constructed and shared ways of knowing within each country. Rice (including its growing and consumption) has strong cultural and social importance in each of the countries in this project.

In Chapter 8, I have already discussed this in relation to the diversity dimension of wicked problems and the findings reflect the challenges of integrating and creating synergies between these different social constructions of reality.

The key social dimensions to consider here relate strongly to the geographical, cultural and political settings in which the project was operating. In Chapter 8, I highlight the importance of cross-cultural differences, and the assumptions, beliefs, symbols and rules that underlie a particular culture. In addition, the political structures and philosophies in each country were quite different. For example, India has a structured, British-style public service and a democratic government, whereas in a country like Lao PDR, it is a communist government, with a strong patronage system (or patron-client relationships) as described by Stuart-Fox (1997). Market systems and market approaches differ widely between the different countries, as do cultural norms and preferences. Cropping systems in particular vary from country to country and have strong cultural and social elements to them. Some of these are covered in the ethical, aesthetic or sympathetic doorways to understanding.

Sympathetic doorway to understanding

The sympathetic way of knowing is concerned with relationships and relating, and the connections to other people or beings or things. This includes concepts such as trust,

relationships, sense of others, leadership, conflict and friendship.

A number of the participants highlighted the importance of the connections and relationships of the project leader including the strong links and relationships with the funding agency. A number of participants talked about some of the challenges associated with the liaison between project and the funding agency. During the course of the project, there were a number of changes of personnel at the funding agency program management level. The implication of this was the need to continually reestablish relationships, as well as some inevitable changes in focus for the project as the personal perspectives brought by different individuals guided and changed to direction and focus of the project.

Members of the project team commented on their project leader's ability to negotiate sensitive issues and to be flexible. He was also respected for his willingness to engage in discussion to resolve and better understand issues and to consult with other team members.

One of the most interesting comments by the project leader was his reflection on creating a whole picture of the project for the team members. He spoke about this as a crucial part of the integration process. He talked about how each disciplinary expert (e.g. social scientists or crop modellers) needed so see where their work fitted into the whole project. He reflected that this was a delicate balance and required judgment calls to allow different parts of the project to take different directions according to expertise and preferences and because of the data sources they did or did not have access to.

He said, "*At the beginning, I was really dominant; really driving. And … I started to realise I had to pull myself out. … And increasingly I've now withdrawn another step and I'm letting the younger people drive what they do in the various countries. … And it sort of gives people more ownership because they have control of it and they sort of pursue things that they feel more comfortable with.*"

There was a lot of discussion about the trans- or interdisciplinary nature of the project and the amount of effort required to bridge across these different knowledge groups and disciplines. Participants talked about the need to talk to each other constantly and the "high transaction costs" of this kind of engagement. For many of the participants,

interacting with frameworks and knowledge systems that were unfamiliar was often very uncomfortable and even stressful. But the participants also emphasised the importance of the good relationships within the team, and the importance of the openness of their colleagues and their willingness to learn from each other.

My own experience in working in and studying this project was particularly rewarding. I immediately felt welcome and valued, and I very much enjoyed interacting with this team of researchers who clearly enjoyed working together and trusted and respected each other. Their ability to question each other and debate issues and approaches without rancour was crucial to such a complex project with many areas of contestation.

The level of challenge in relating and relationships was increased with the distances between each of the five country teams. A number of participants commented that not being able to talk face to face regularly made the interaction and communication much more challenging. In addition, the number of different organisations also increased the challenge and complexity.

CS3D said, *"So if you're moving into a new area, how do you target those people that are likely to be in those household types that could benefit from these adaptations. And we need to develop the packages in a way that can fit in with existing I guess knowledge networks and institutional structures, etc. So there's a bit of learning that we need to do to take those steps."*

One of the most vivid examples is the ability (or not) to create a sympathetic bond beyond cultural boundaries. This presents challenges, given the difficulties of creating common understandings and pattern recognition. The interviews highlighted a wide range of perspectives on how the various team members were able to achieve this to a greater or lesser extent.

One of the ways in which the climate adaptation case study stood out from the other two, was the discussion of the level of trust and comfort the participants expressed between each other. This was also reflected in the generally relaxed, friendly atmosphere that I observed in all my interactions with the team members. There was general agreement that it was okay to ask difficult questions, and that they all felt safe in venturing into unknown or new areas or ways of working.

Untangling the physical and social ways of knowing

The physical question includes questions about the material world and the evidence of the senses answered through measurement and observation. It includes things that can be measured, counted, visualised and observed. The Enlightenment has brought the physical question to the fore, almost to the exclusion of the other questions. The trap associated with the physical is that (like the other ways of knowing) it is almost impossible to consider separately from the other ways of knowing, with objectivity, rigour and accuracy touted as the ideal. But the physical never stands on alone – we are always interpreting it. To measure the physical requires abstraction and social construction. For example, the kind of laboratory experiments described by Latour and Woolgar (1986) require a certain kind of knowledge and agreement about the results to interpret the experiments. That while the results of these laboratory experiments and the conclusions drawn are regarded as "physical" phenomena, the means to do these studies and draw conclusions requires agreement between the researchers about how this should be done. This process is a social construction. This can create confusion about what is physical and what is social and can also lead to a reification of the social construction into something seemingly real and tangible. It also makes the disciplinary division between "social" and "physical" sciences less clear.

A false dichotomy or dualism emerged from my interviews – between what the participants termed "biophysical scientists" and "social scientists" whereas the reality was much more complex and nuanced. Team members were either referred to as biophysical or social scientists, rather than as social anthropologists, sociologists, and economists for example. However, the biophysical scientists were frequently described as "crop modeller", "climate scientist", "soil scientist" or "agronomist". This is an interesting distinction which highlights the dominance of the biophysical sciences in the lead organisation for this project. In addition, the divisions between "physical" and "social" varied and were unclear.

A number of interviewees recounted to me the story of the reactions to a social scientist being appointed as Deputy Project Leader – which in many cases included some shock and consternation, and it was certainly regarded as unusual. However, there seemed to be some marked shifts in attitude by the "physical" scientists towards the "social"

scientists over time, as they became more used to working together.

One of the researchers said, *"I guess in most projects I have been in, social science has provided context to the agronomic … to the biophysical stuff, but was always a service provider, if you like, to that. This [project] is very different to that where it's social science as an equal … or I'd say it's an equal and doing their own research in their own right and still supporting what we are doing but to a lesser degree probably."*

Much of the evidence presented at the mid-term review pointed to changes to the cropping system (which was largely framed as a physical system despite being a social system as well) having limited impact or scope for climate variability adaptation. Issues of migration and diversification (social issues) seemed to predominate at the household level. However, this was counteracted by the clear focus by the national governments of these countries on physically increasing production of rice.

Modelling (both crop modelling and climate modelling) is an interesting illustration of the intertwined nature of the physical and the social. The APSIM (Agricultural Production Systems Simulator) is a good example. A number of the interviewees talked a great deal about developing this model, which was used as a way of modelling cropping processes, including plant, soil, climate and management processes. The process of developing the model was described as highly intensive, requiring a large amount of data, but potentially meaning that, eventually, the outcome of cropping decisions and practices could be forecast for a particular seasonal scenario. I found it difficult to gain an understanding of why it was important to spend so much of the projects resources on this – the application and use to meet the goals of the project were not spelled out, though we were provided with information about how many scientists had been trained, how many papers published, but not much about the possible impacts of its use – this knowledge seemed to be assumed. While the researchers had been working with highly computer literate and technologically advanced farmers in Australia, the farming communities they came into in each of these countries were struggling with far more fundamental issues, and a large proportion were subsistence farmers.

While it was described as a physical model, I see the process of constructing such a simulation model is also a social one, and at to a large extent socially constructed. One

of the participants described it as, *"one of the rare examples of [a] long-term modelling group, who continue to get funding and continue to keep publishing and producing useful applications of the model"*. He saw maintaining critical mass as one of the key sustainability elements, in terms of maintaining the number of users and contributors.

One of the questions about using such a forecasting model was that it focuses primarily on fine adjustments to cropping and the cropping management system. It does not interact with the larger systemic and social issues such as labour scarcity, remittances, mechanisation, finance, market access, cost of water, etc., (nor is there any claim that it does) which appeared to be dominant issues in the project. This raises questions (unanswered) about how such modelling efforts link in with the goals of the project.

Conclusions

Using the five doorways to understanding to pose inquiry questions and (in this case) to interpret the findings provides some additional insights and perspectives that may have been useful in furthering integration and synergy between the different worldviews and approaches. For example, the ethical doorway provides insights into some of the challenges associated with policy engagement, highlighting differences in values, principles and aims between different stakeholders which might not otherwise surface.

The five doorways do not provide an alternative to disciplinary inquiry and the methods and approaches associated with these, but provide a means to create coherence and synergy between them and to generate research questions that reflect a broader range of understanding.

In addition, these doorways may be helpful in cutting through the assumption that decision-making is largely rational and driven purely by incentives such as economic gain. The reality is that decision-making by humans is far more nuanced. In the case of the Laotians I describe in this chapter – they will still grow sticky rice in the face of potential higher yields and economic returns from growing other kinds of rice because it is culturally and socially accepted and their aesthetic preference is for the taste and texture of sticky rice.

A final point is to do with power asymmetry, and the fundamental issue that some kinds

of knowledge are considered “better”, and dominate and trump other kinds of knowledge. Given the relativity of power (as described in Chapter 6 analytical framework), if you are the largest shark in the sea, being in the water does not seem dangerous, which means that this power asymmetry is not generally visible to the more powerful actors. Brown’s (2008) knowledge cultures highlight the power imbalance between the nested systems of individual, local, specialist and institutional knowledge, with each one progressively trumping the previous one in the list. She says that only through a holistic approach to knowledge can we deal constructively with these power imbalances.

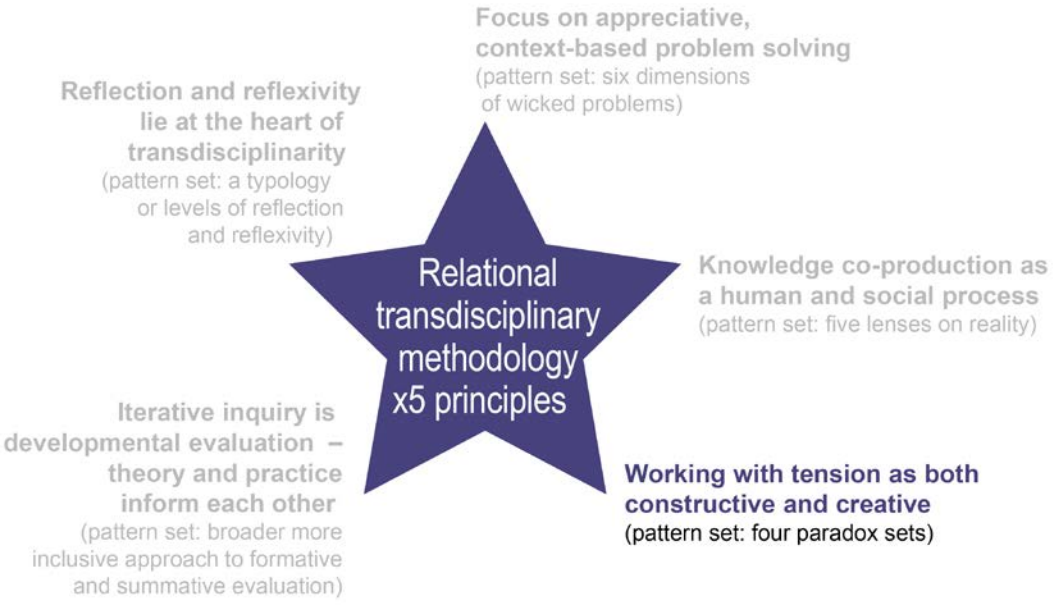
In all the projects I studied, physical scientists were the project leaders and program managers, with social scientists tending to play a subsidiary role. Even further down the “pecking order” were those actors who were not researchers, but who had other (equally valid) forms of expertise and knowledge. Although I do not focus specifically on gender dynamics in this thesis, it is important to mention briefly here that male researchers predominated in the leadership roles and were predominantly the biophysical scientists. The exception to this was Case Study 2, which was a team made up almost entirely of women (something I have never before experienced in my research career).

While the projects self-identified as transdisciplinary, they could not be classified as such in the broader sense. Though each project team saw (to a greater or lesser extent) the importance of striving for transdisciplinarity and the need for a breadth of knowledge, but the participants often lacked the tools, imprimatur or awareness to be able to effectively engage with this. In each case study, the physical sciences were the dominant knowledge set (trumped only by the institutional wisdom mainly of the donor where the physical sciences were also frequently dominant). However, it is clear that this is in many instances changing. A good example from the findings is the appointment of a social scientist as deputy project leader. This initially caused quite a stir, and some protestation, though later acceptance. So the social way of knowing or doorway was also to some degree well-recognised and represented in the project.

CHAPTER 10
WORKING WITH TENSION AS BOTH CONSTRUCTIVE AND CREATIVE

How wonderful that we have met with a paradox. Now we have some hope of making progress.

(Niels Bohr)



The third principle outlined in the research methods and design is working with tension as both constructive and creative. This tension can come from a number of sources including double binds, dualisms, dichotomies, paradoxes and pattern mismatches. In particular, in Chapter 5 I show how a more constructive and creative approach to mediating between seeming opposites breaks down the binary thinking which has dominated thinking since the Enlightenment, and is inherent in positivist and post-positivist approaches to research. The point here is that the tension or "dynamic balance" between two seeming polar opposites has generally been regarded as something to avoid, or try to eliminate in research (and indeed in everyday life to some extent). It can also be described as binary thinking, where something can be either A or B, not both and not C.

The first of these, the double bind, comes from Bateson, who talks about a situation

with two equally unpalatable options (Visser, 2003). A dualism, according to the Australian Macquarie Dictionary, is a "theory holding that there are two, and only two, basic and irreducible principles, such as mind and body". Ansell describes Dewey's work in seeking to overcome a series of dualisms that he perceived to be "poisoning modern thought and life" (2011, p. 122). Dewey included the following dualisms in his list: individual and society; subject and object; mind and body; thought and action; and reason and emotion among others. Dewey primarily relied on recursiveness as a technique to overcome dualism. As outlined in Chapter 6, I have framed these various tensions as paradoxes, and used four of these as the pattern set to operationalise this principle. These four are parts and wholes, stability and chaos, creativity and rationality and individual and society, as outlined by Brown and Harris (2014).

In this chapter, I am seeking firstly to discover examples of seeming paradoxes and how they are perceived by the researchers, and to look at whether and how this tension has been, and can be, exploited for creativity, innovation and change.

Individuals and society – bridging scales for climate adaptation

Social change (including the research problem) is highly complex and requires "recognising the impossibility to isolate single elementary units and the necessity to link the knowledge of any elements to the knowledge of the wholes they belong to" (Alhadeff-Jones, 2010, p. 480, in Fenwick et al., 2011, p. 23). In other words, the individuals cannot be referred to without linking them to the various elements of the society they are embedded in, nor can "society" be invoked without reference to the individuals and sub-groups of which it is comprised.

The Case Study 3 project aimed to demonstrate real progress in improving rural households' ability to adapt to climate variability and change, while at the same time providing evidence to guide the development of national policy for climate adaptation. This was a significant challenge. The seemingly paradoxical tension around individuals and society was a central issue and focus for the CS3 project, and the need to "bridge these two scales" (Roth & Grunbuhel, 2012, p. 430). The research team was focused on this from the start and there was extensive discussion and debate about how to tackle this both in the interviews, and in the project meetings and workshops I attended.

The project is described as combining a "top down" and "bottom up" approach to develop multi-scale climate adaptation strategies for farming communities, providing practical farm-level options right up to providing options for national policy directions in four different countries in the Mekong and South Asia. The research gap identified as the "niche" to be addressed in this project was the bridging between national and local scale efforts (Roth & Grunbuhel, 2012).

Roth and Grunbuhel describe the conceptual framework as an *"adaptation cycle … on which to base a reflective analysis-action continuum that connects science with society at every step"* (2012, p. 430). This clearly encompasses a recursive and reflective process to create the third mediating space. These two processes will be described in more detail in the next two chapters as key approaches to dealing with the tension of paradoxical or dualistic situations through an iterative/recursive approach and through systemic and habitual reflection.

There was much discussion in interviews, meetings and papers about how to bring together these seeming opposites – farm households and national policy frameworks, up-scaling and out-scaling, strategies and practices. Roth and Grunbuhel illustrate this in their description of "generalised national scale studies" versus "complex sets of case studies without generalisation", where the "generalities are too non-specific for regional local action" and "case studies are too specific (non-comparable) to transfer elsewhere" (2012, p. 430).

Roth and Grunbuhel state this clearly in relation to Case Study 3, saying, "*… there is a major disconnection between national scale climate change vulnerability and impact assessments carried out as part of the IPCC and NAPA assessments on one hand, and adaptation interventions at the household and community level that are mainly being led by NGOs on the other hand*." (2013, p. 426). They identified bridging this divide as a key niche for the Case Study 3 project, in particular, focusing on a multi-scale approach using "ground-truthed" adaptation options for generalisation and up-scaling rather than a "top-down" approach applying generic solutions locally.

The solution proposed in the project was to develop a series of household typologies to simplify the complexity and diversity of household characteristics which could be a linking mechanism between national policy and household adaptation. The purpose of

these typologies is outlined in a paper on the social science framework for the project.

> The ultimate goal of the household typology is a description of different types of households that is simultaneously locally relevant (that is, types can be extrapolated to similar geographical areas) [and nationally applicable]. This cannot be achieved without the use of adaptive capacity self-assessments [by the farmers], without which types would remain quantitative measurement removed from local meaning.
>
> "The aim of linking self-assessments with the typologies is to be able to go beyond the local scale and make statements on regions and nations without losing the relation to household decision-making. At the same time, we have to take into account emerging properties and supra-local drivers that may arise as we move up the scales … (e.g. communes, districts, provinces, regions etc.) We assume that national statistics are collected along those same scales and the household types can be related to variables found in the official statistics reports.
>
> (Williams et al., 2013)

I have interpreted this as a process of moving beyond an idea of incompatible opposites of individual and society, to constructively create a third mediating space (through the typologies). It also acknowledges the importance of local knowledge – in the requirement for adaptive capacity self-assessments, and the need to ensure there is local meaning, and at the same time correspond with the kind of knowledge and information gathering that occurs at provincial and national scales. The typologies were an attempt to group the local characteristics which would have some correspondence with the kind of variables and data collected at the national scale, without losing local meaning and importance. This approach was articulated by some but not all researchers as the following examples show.

CS3B summed this up thus: *"And the beauty of the project is that it is working at different scales, so it's working at farmer community level, but then also at a scale where they want to influence the decision-making process …"*

CS3E: *"So at the local level we talk very much about households and the practices, so the changing in the water regime or a different crop or whatever. At the policy level,*

we're thinking it will be more appropriate to use the household types and a more broad livelihood strategy."

CS3G: **"***… It's not being prescriptive and saying, 'This is what you must tell farmers', but it may be useful to tell policy makers, 'We've identified six types of people in this region, but we actually think in 20 years' time, the very poorest type is not really likely to exist anymore'. … So it may be more useful to help them to transition out of agriculture … but just focus on government resources and ways in which they would be most used by the population. … It's more 'here is a range of options which we think may work'."*

CS3B highlighted the diversity at the local level and then contrasted this with the need for national level policy change and the need to engage in the "third space" mediating between individual and society. **"***So I think the biggest challenge is the uniqueness of households and individuals, because people's aspirations, their ability and capabilities are all different, and I think what is clearly, clearly required is either you get down to a scale where you are addressing those needs, or at a larger scale you are implementing primers, primers from a point of view that you have an intervention that results in change. … When you are looking at a national scale, you are looking for those interventions that will result in a change. But often they are very hard to find, but when you're looking at a much lower scale, I think the typology approach that the [project team] has taken is really, I think, innovative."*

The participants highlighted a gap in this approach (as I outline in Chapter 9). Despite the deliberate bridging of scales, the policy engagement process was in some cases not as comprehensive, or was not comprehensively tackled until the second half of the project. This highlights one of the difficulties and challenges of this kind of broad-based work. With a strong focus on field trials and farmer-based activities, there was little funding, time or expertise to research the national and provincial perspectives and situations. The reasons for this are not clear, but I suggest that this is a familiar challenge in similar research for development projects, and is often not conceptualised as "research" but rather as "implementation", and the appropriate expertise is not necessarily included in the team.

Parts and wholes

System scale was also a key consideration in exploring knowledge production as a human and social process. While using the five doorways or lenses to understanding is a very useful bridging, dialectic and analytical tool, there needs to be an additional element – that of a multi-scale view and different system levels and focus. For example, the understanding gained from looking at the rice-paddy level system or a household system will vary greatly from that at the national or international system level, and there are multiple conceptions of these systems to consider. Another aspect of operating at different scales of systems and realities (which this project did) is the importance of reworking and re-imagining the seeming paradox of parts and wholes.

“Reflecting on the patterns that connect is more important than concentrating on the differences that divide” (Brown and Harris, 2014). Every part is itself a whole, and the whole relies on the strength of each of the parts. This is a particular challenge thrown up by Enlightenment science, where the response to complexity and multiplicity has been to “break it down” to a small number of variables and focus on knowing a great deal about a small aspect of the system. While this has been an enormously successful approach, it is insufficient by itself. In particular, a careful study of the parts does not add up to a picture of the whole.

This also applies to the process of transdisciplinary research design and practice. Transdisciplinarity is not the sum of the various disciplines and “non-disciplines” inquiry and activities, it requires a synergistic and coherent approach where the whole becomes more than the parts.

One of the key themes to emerge from the discussions, documents and interviews for Case Study 3, was the question of (what the project team called) integration. Integration was talked about as a sort of Holy Grail for the project – and the researchers frequently asked themselves, “How well are we integrating?” “How will we know we are integrating our research?” and so on. I have interpreted this as being at least in part a question of parts and a synergistic whole. There was also discussion about whether the team was achieving transdisciplinarity or was still at the interdisciplinary level. In this discussion, transdisciplinarity emerges clearly as being about synergy and the whole

being more than the parts.

The project leader was of the view that the team had managed to achieve interdisciplinarity, but that transdisciplinarity was still a desirable but unachieved goal. He highlighted the lack of equal engagement with the non-researcher stakeholders in the project and considered how this could be done more effectively in future projects.

There are many ways of looking at this project as a system created by the relationships between parts and wholes, including a project team made up of many different disciplines, a collaborative alliance between different organisations, an international partnership, and a project bridging all of the knowledge cultures, including individual, local, specialist, organisational and holistic. None of these are necessarily more important than any other but are all part of the system and various subsystems. In addition, there are the systems, such as rice-paddy, community, regional and national systems (complete with parts and wholes) which were the subject of the research, and the way in which each of the parts and wholes are interpreted in these systems. Each can be looked at as cases for conflict, or a relationship system.

CS3C said, *"It's really interesting because the people who try to look at what are the determinants of integration and success of integration and how do you do it? And I never ever posed that question to myself. I think to some degree having gone through this process that facilitates integration, because it makes explicit which bits have to come from whom. It defines the role of the social scientist and it brings it to a common language of achieving, not just objectives which is too fluffy, but right down to tasks and how these tasks are linked and how one output from one task is the input to something else. … Yeah. So the whole team had to go through that. Although maybe only one activity was relevant to the social scientists, they had to go through the thinking of all the other stuff. And likewise the modellers could see how the social stuff fitted in."*

This description clearly highlights the importance of seeing the relationships between the parts as well as understanding the "essence" of the whole. Without that "essence", the project would have been simply a series of smaller, separate, disciplinary and national/sub-national projects. As I outline in the review of literature in Chapter 4, this approach is still more generally a work in progress. It appeared to be still a challenge for

many of the disciplinary experts to embrace a broader view or accommodate different worldviews and approaches (and at the same time focusing on their own work). On the positive side, as I have described in the account of the mid-term review in the following chapter, there was a strong focus on seeing the bigger picture of the project as a whole.

It is important to note here that the "essence" seen by each of the participants was not the same, nor did it need to be. In fact, different views and pictures of the whole and the parts are essential to open up more possibilities for solutions and to challenge existing or embedded thinking for evolutionary and collective learning.

CS3L reflected on what he saw as the challenges of integrated research. *"Unless you design [the research] in an interdisciplinary and integrated way and link it from the beginning itself. If you design it as components and only at the end try to bring it together it won't work. Like now, with X (scientist), we can talk socio-economics, … and he will understand it. Now he talks and defends it – 'this is the typology'. And we know what they are doing too."*

CS3E described the integration process from her point of view. *"I have not worked in another project of this size with this many different components between the modelling and climate and field trials, and where we have the opportunity in a room together to talk through these kind of methods where integration is not just 'you do your bit, we'll do our bit and at the end of the project we'll write a report'. It's actually 'we'll work together and make sure as we go through that the frameworks we use force us to [work together]'."*

Not everyone was so positive about the integration. CS3F said, *"There's been a lot of talk in the project team … about how we integrate. A lot of these discussions, as far as I can see, go round and round in circles. They are not really coming up with anything, and I think that they need to say, 'Okay, how do we integrate things to give information to the policy people, because the question of how they integrate is going to be determined by what are you trying to get out of this information and what sort of information do you want to give people'."*

There is an interesting difference between these two statements. The first is about approach and research practice, and the second is about information and about how to

combine information. These are two categorically different definitions of integration which speak to the very different world-views of these two participants.

Other reflections focused on the challenge of taking a whole picture approach, but not taking on too many parts. CS3D: "S*o yeah, I mean it's one of the things you've got to be aware of … there's got to be some sort of limit you can't even do well enough what you are trying to do let alone take on more."*

This was strongly reflected in the discussion about whether livestock components of the rice-based farming systems were "in" the study or "out". This debate seemed to have continued from the very early stages of scoping the project, with the funding agency very clearly putting livestock out of scope, despite many of the project team members expressing the opinion that livestock components in these systems provided critical adaptation and diversification options.

CS3P reflected on this, saying, *"In an ideal world it would've been nice to have animal production in there, but I suspect... I can see why it wasn't in there. It would've made a huge project. It would've possibly diverted or distracted attention and interest in particular areas. The reality is that rice is the basis of the food security system and that was probably where it was logical to start. But having said all that, in the future, animals have to be part of any project I think."*

The absence of livestock was commented on in the mid-term reviewers' report,

> The role of livestock within rice-based systems as a complementary livelihood and as a "bank" is well understood. This was highlighted by the field trip, according to the background notes, the 158 families farmed 115 ha of rice but also had "287 cattle, 85 buffaloes, 432 pigs and about 3,461 poultry …" The role that these livestock play in labour requirements and as a means of managing climate risk raises interesting questions. Those questions may be falling between the description of the household typologies and the detailed modelling.

But the reviewers went on to acknowledge, *"Managing scope is difficult in any project. Scope is clearly going to be a challenge in a multidisciplinary, multinational project. Furthermore, notions of adaptation, climate change, and farming systems are elastic terms that can be stretched to include almost anything. … There is no simple answer*

…" The reviewers provided a number of suggestions as to how this could be managed, focusing largely on the concept of boundary setting, rather than parts and wholes. It is clearly impossible to be "complete" in developing a systems view; instead, there is the option of constructing a series of system "levels" rather than trying to be exhaustive. The other important strategy which the project team adopted was to link with other research and development projects which were tackling some of the system issues that were beyond scope for CS3, rather than operating separately from the many development activities surrounding them. Instead of seeing other projects as competition, they saw them as potential opportunities, relationships and partnerships.

Stability and chaos

In this large, complex project, many participants commented about a tendency to "messiness" and the difficulty in keeping the project organised. A useful way to view this is through the lens of the third seeming paradox – that of stability and chaos.

"Thinking about a system as stable and chaotic at the same time is a difficult mental summersault" (Brown & Harris, 2014). Crutchfield, Ramalingam and others discuss the importance of the stability (or order) and chaos as being central to the concept and operation of a self-organising system – that a dynamic self-organising (or organised complex) system tilts between stability and chaos constantly. Fenwick et al. quote Ilya Prigogine's description of the use of complexity science as a "means to overcome the false dichotomy between determinism (predictability) and a state of chaos" (p. 19).

In Chapter 9, the different dimensions of wickidity (beyond complexity) were mapped against Ashhurst's wicked problems dimensions model which highlighted the enormous variation in issues and perceptions of issues. The analysis highlighted stability and instability, as well as intractability of the research problem and context.

The simultaneous presence of stability and instability (or chaos) was reflected in the household typologies as described here. CS3E grappled with the difficulties of creating a typology in a system which is both stable, and unpredictable or chaotic, "*So our experience with the [typologies] has sort of led to this realisation that households are dynamic and the types don't reflect this necessarily. So when you have a household typology that's sort of defined on one hand by resources, which is kind of quantifiable*

but then on the other hand, livelihood strategy which is dynamic and constantly changing and re-evaluated …"

CS3K, who worked with the funding agency, talked about the need to take an adaptive approach to deal with the unpredictability in the system (as well as the unknowns) saying, *"… when we start a project we don't know everything, therefore having the intelligence and the systems to allow us to adapt the project rapidly without much drama."* He adds that he thinks the funding agency is good at this but questions whether the scientists are. This was in contrast to the researchers, who (in a number of cases) expressed the opinions that the funding agency could have been more adaptive and flexible and focused less on linear and prescriptive planning approaches.

The project itself required an ability to not only work with stability and chaos at the same time, but to use this as a source of creativity and emergence of new ideas and approaches. The project leader talked about the process of planning the project and the detailed log frames, budget and activity spreadsheets he developed. He describes this as a long, drawn out and complicated process: *"… what I did, and leading into the actual final proposal, I went through a series of country workshops where together with the prospective partners I workshopped what the project was going to do, you know, the objectives, … I didn't explicitly think I was going to do a log frame. I just ended up doing a pretty hierarchical sort of aim, objective, activities …*

"And it was painful. It took ages to work through these things [with all the partners]. Feedback out of it was really incredible. So the [country partner] guys said, 'It's really hard work, but now we know what we have to do'. Now, projects change. They're not static. So what then happens is …"

He said, *"I had pretty tight control over this beast at the beginning. And as things got going, and I got to see people shape up and perform, I know where I can let go with little risk and I know where to keep a pretty tight control."*

CS3F said, *"I've got a lot of faith in [the project leader]. He scared me early in the project when I saw how he manages his funds. … And he's got this huge big spreadsheet with everything in there … everything broken up with all the sub-things and then it goes down to his bottom line."*

This mix of chaos and organisation was reflected by CS3P in his description of the project development process and implementation in one of the provinces. *"Well, initially … because of the timing of things, theoretically it should've been … the social science component identifying typologies etc. before [the field trials started], but it hasn't transpired, just because of timing, and we tended to identify villages and things where we wanted to work before [the typologies]. We identified different systems, cropping systems that we thought … were major systems of the district … the region anyway, but had some opportunities to modify to possibly improve the resilience of the system, and through that, the resilience to climate variability and maybe change."*

The combination of stability and chaos played out not just in the organisation and running of the project, but in the study itself. Rice systems themselves were described as simultaneously chaotic and stable systems by the participants. There were a number of discussions and accounts of difficulties due to drought and unpredictable events. Within the project itself, there were a number of discussions and accounts of difficulties in getting adequate field data – setting up and completing field trials – for a range of reasons including unpredictable weather, lack of coordination within the team, misunderstandings etc.

Creativity and rationality

This paradoxical "grouping" – creativity and rationality – encompasses a number of dualistic descriptions, including gestalt versus logical thinking, concrete experience versus abstract rationality, qualitative versus quantitative approaches, subjective versus objective, interpretive versus analytical, intuitive leaps versus stepwise analysis etc. It incorporates different, seemingly incompatible ways of knowing. One basis of Enlightenment thinking was the separation of creativity and rationality. And the rationale is that we use either one or the other. But the reality is that they are inseparable in human thought. The question of whether they have been separated and how and whether they can be brought back together has been argued by C.P. Snow in his "two cultures", by Isaiah Berlin and also by Kuhn among others. Similarly, the Pragmatists talked about the need to bring together concrete experience, reflection, abstract rationality and active experimentation to create learning, in particular what I am describing as collective learning.

The project leader gave a number of examples of the need, and his ability, to bring together creativity and rationality. He told me that he needed to have a rational, logical way of organising the project, but also to be able to make intuitive leaps and allow for creativity and some disorganisation and messiness, as well as to embrace the more interpretative research activities in the project. While this is not necessarily a unique approach (though by no means universal) the important thing to note here is that he is doing this reflexively as well as intuitively. He is consciously combining creativity and rationality to find new ways to view and to solve problems and to deal with the challenges of the project.

I asked the project leader what advice he would give to an aspiring research team leader and he said, *"I think first of all you need the passion for the project. I mean everyone tells me I'm passionate about the project."* He went on to acknowledge that he is using his "heart" as well as his "head" as leader of the project – engaging both rational thinking and his emotions to create the third space for constructive synergy – a process of collective thinking and reflection. In the extended time I spent with CS3C, he clearly practiced what he preached. He was respected by his team who said that he took a personal interest in the activities and well-being of each of them. He was also enthusiastic and passionate in the way he spoke and acted in relation to the project. While he showed me incredibly detailed spreadsheets covering expenditure, outputs and outcomes, he could also be creative and responsive – allowing for a more dynamic and iterative approach to the project implementation. While he planned in meticulous detail, he reported that he was happy to make quite spontaneous decisions and actions.

Another example is the working relationship which developed between researchers and farmers, bringing together their different ways of knowing and thinking. This brings together not only "heart" and "head", but also "hands". One of the partner country scientists told me a story of working with a group of farmers, whom he initially felt were not following the advice and recommendations that the scientists were giving them.

CS3N talked about the way in which the farmers knowledge (based on a long history of practical experience) came together with the more quantitative approaches of the researchers to create a synergistic outcome. *"[Before], they knew that there was some rainfall. Now they are sure of just how much rainfall and compared it with the advisory*

we were giving and found it useful. Now we get phone calls from them [asking for advice]."

This is an example of two very different modes of thinking brought together – between the scientists and the farmers, which could perhaps be described as concrete experience versus abstract rationality. This is an oversimplification, as there are elements of both in each of their thinking, but the combination of the two is a powerful combination for problem solving. This particular "third space" is well utilised by many Australian scientists and farmers but not necessarily in a reflexive way. The point here is that both ways of knowing are needed for transdisciplinary research, but the challenge is to produce evolutionary learning, through three conditions: a problem-driven perspective, reflexivity and deliberation (Ansell, 2011).

This creativity and rationality paradox also came into play in the interactions between the biophysical scientists and the social scientists – bringing together different ways of thinking and knowing. CS3P (a biophysical scientist) talked about it from his perspective. In Chapter 8, I describe the disconnects and misunderstandings between some of the biophysical scientists and the social scientists.

This highlights the difficulty of bridging between two seemingly incompatible ways of thinking (in this case, the more interpretive approach of the social anthropologists and the empirical and more technically-based approach of the agronomists). The biophysical researchers and the social scientists were approaching this in fundamentally different ways and bringing different ways of knowing and modes of inquiry to the research. An alternative approach to this is to see it as an opportunity for learning and creativity, and to acknowledge that by asking questions and pursuing inquiry from a very different standpoint, with a different set of assumptions, they have the potential to uncover a different and complementary set of information.

The social scientists were in many cases well aware of the views of the biophysical scientists, and in this case, highlighted another issue – that of the biophysical science knowledge being privileged above social science knowledge. CS3G, a social scientist, said *"So I think the [biophysical scientists] have an inherent understanding of the socioeconomics … of the landscapes in which they do APSIM modelling, it's just that they … aren't used to it sort of speaking out loud. So some of the resistance, I think, was*

just, 'well, this is new and different', rather than 'There's no need for that'. I mean [social scientists] are scientists like everyone else, they're not, you know, airy fairy nutters, they're kind of grounded in reality … They have areas of research and frameworks, and I suspect, unfairly, have had to prove themselves far more than biophysical scientists have to. So in some ways they are far more rigorous than some of the biophysical scientists. I think … social scientists get a bad rap and so they have to work twice as hard as other people to be in the same place."

This narrative and the clearly different views of the two participants, highlights a lost opportunity for synergy. Privileging the biophysical knowledge over other ways of knowing precludes the kind of positive deliberation and creative tension that would have been useful here.

Summary

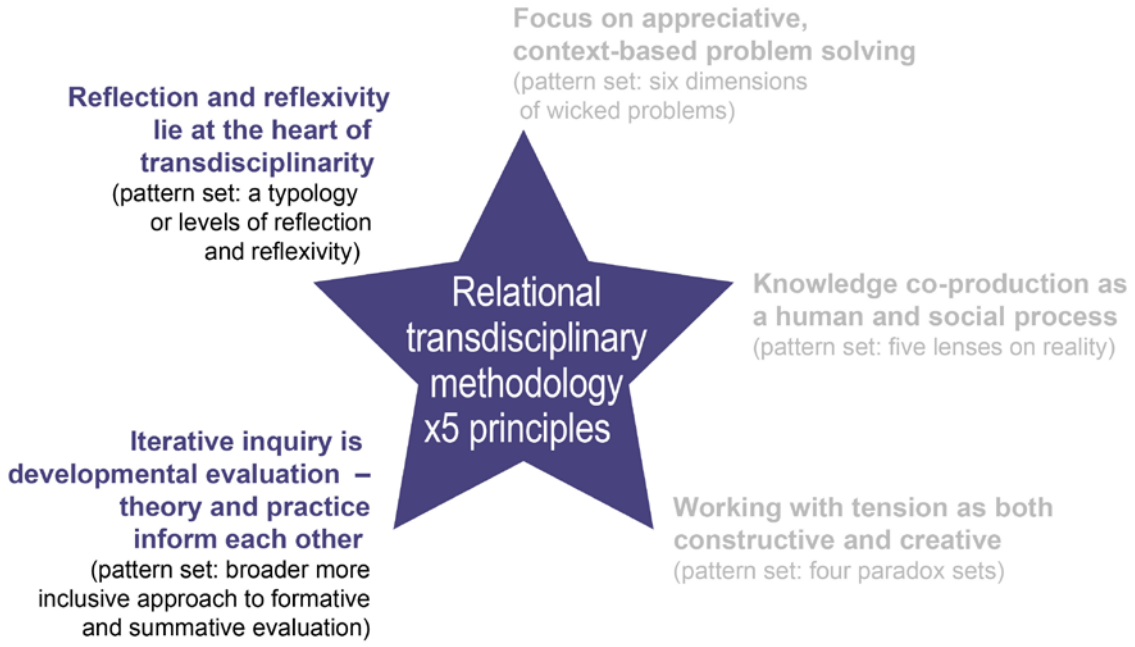
Framing a series of seeming paradoxes or false dichotomies (resulting from Enlightenment approaches to thinking) as identified here provides a potentially very useful tool for exploring some of the tensions and dissonances as well as the rich opportunities for triple-loop learning in this and other projects. The level of awareness of many of the participants of the presence of this tension, and their ability to not only tolerate it but to exploit it, is a very positive aspect of this project. It created greater opportunities for collaboration and sharing of ideas (without requiring consensus).

In the examples above, the seeming paradoxes were actively and in many cases reflexively discussed by the participants. These discussions were crucial to tackling the complexity, diversity and wickidity of the research problem and environment. This kind of discussion not only highlights challenges and issues that need to be debated and discussed by transdisciplinary research teams, but also opens up opportunities for new solutions. While I believe this recognition of tensions is critical to successful transdisciplinary rural research for development (and a broader array of complex systems research), there is still a key step or approach needed to turn these opportunities into successful research outcomes. Bringing together such a diversity of views and approaches, and dealing with a series of paradoxes requires a common set of questions to drive the process of problem resolution.

CHAPTER 11
ITERATIVE INQUIRY AND REFLECTION

The teacher, if indeed wise, does not bid you to enter the house of their wisdom, but leads you to the threshold of your own mind.

(Kahlil Gibran)



In this chapter, I have investigated both the fourth and fifth principle – that iterative inquiry is developmental evaluation and reflection and reflexivity by the team and its individuals. This findings chapter is less comprehensive than the previous three chapters. I have particularly chosen to emphasise these two principles less, as they are widely and comprehensively documented in the literature already as key components and requirements for transdisciplinary research design and practice. However, I have included them briefly due to their importance and primacy in transdisciplinary research, and their importance in applying the first three principles. I have primarily focused on the data from the mid-term review session to look at how the team and the reviewers approached the review and their response and feedback.

Mid-term review of climate adaptation project

The mid-term review of the climate adaptation project was held in Phnom Penh in Cambodia. It seemed to be a pivotal point of the project from a number of perspectives. Firstly, it was the first time many of the teams had met each other (particularly from the various countries). Secondly, it was the turning point for the rest of the project – review and onward planning came together during this event. Thirdly, there was an accountability element as well as a chance to reflect on progress so far.

The project leader talked about this as being quite a juggling act. He talked about having to script it tightly to give the right impressions and to convey relevant information. He was grappling with the problem of communicating progress to date in a highly complex, very detailed, very large project.

Unsurprisingly, the review team were overwhelmed with information. A number of the project team members expressed disappointment that the reviewers didn't read the review synthesis in more detail – and some of the other team members were disappointed and a bit indignant that their work seemed to have been either overlooked or not understood.

In summary, some of the key challenges for the project team, and particularly the project leader, in organising the review workshop were as follows:

1. Tension between the resources available for the review versus the extent of the project.
2. The changes in brief over time (moving goal posts) – personnel changes at the funding agency, changes in policy directions (e.g. the advent of the food security priorities and the seeming clash with the climate adaptation priorities) – tracking this through a traditional review process is very difficult.
3. The sheer size and complexity of the project – so many strands to bring together.
4. The need to combine accountability assessment plus planning plus critical reflection. And all of this with a very large and diverse team, many of whom were meeting each other for the first time.

The first session at the mid-term review grounded us clearly in the context of each of the study areas, and the households that the researchers were working with. Each of the presenters outlined the complexities and challenges of the household systems in their area and the policy, social and other factors affecting their situations and trajectories. The differences between the household systems were very marked. For example, the Bangladesh project group talked about a focus on salinity encroachment, landlessness, and diversification into shrimp production. In Laos, the focus was on labour migration, the importance of off-farm income and remittances. In Cambodia, the farmers were very dependent on Vietnamese traders and a system of credit for inputs and the harvest.

After this the presentations shifted to other activities in the project, including field trial results and climate information, with each disciplinary or interdisciplinary group presenting on their own work.

The review report

In their report, submitted following the review meeting, the reviewers' first statement was about needing clarity and reduction of complexity. They highlighted the need for some simple, clear messages around what the project was about and what it was achieving. This was highlighted by the fact that it appears to have been unclear to them that the project design was based around the sustainable livelihoods framework. When I looked at the synthesis report, I had to look hard to find it mentioned. But I knew to look for it and the reviewers did not.

The report did reference a working paper (Williams et al., 2013) which clearly outlined the methodology, theoretical foundations and underlying assumptions. However, I only found this paper later on the lead organisation's website. The reviewers comments would tend to indicate that they also did not have this crucial document. In addition, while sustainable rural livelihoods was the underpinning framework, the research process and methods which were developed around this (and this can be done in a myriad of ways) were not clearly linked back to this framework.

There seemed to me to be a number of misunderstandings or disconnects between the reviewers' report and what I was hearing from the team. A number of instances crop up in the recommendations.

For example, in observation 6 in the reviewers' report: Climate change modelling refers to a "*general conclusion that there is limited negative impact to agricultural productivity by 2030 and it is best to get on with managing climate variability and building adaptive capacity*". In addition to this but separately, the thesis research data indicates that in general the farmers are simply not interested in 2030, and more immediate issues of improving risk management and adapting to climate variability were far more relevant and urgent, and would contribute to the 2030 adaptation options. This raises questions about the focus and relevance of the modelling as the central focus of this particular project. This also highlights the challenges of prediction in self-organising systems (or organised complexity) as described by Ramalingam (2013).

The standard review format makes it difficult to really see what the project has achieved. The outputs and milestones are tabulated and the reviewers have commented in another column. This seems to work against the desire for "integration" and for a holistic view of what has happened – so parts at the expense of the whole.

The reviewers themselves commented on their inability to conduct any independent inquiries due to the nature of the process mapped out. Their input was limited to the PowerPoint presentations, reports, and informal discussions at mealtimes between workshop sessions and travel time during the field trip.

The structured nature of the workshop inhibited this, but on the other hand, it allowed the various research partners to each have their say, and to have some time to present their work. Again, a wicked problem – how to meet all the aspirations and goals in one short workshop.

The review team included a section on impacts in their report (according to the funding agency's template) including scientific, capacity building, and economic and social impacts. They highlighted three issues in assessing impacts – short timeframe, review process structure and difficulty in establishing attribution, given the number of similar programs operating in the region.

This is a fundamental issue for research for development. Given the number of donors in a country at any time and the volume of active projects at any particular time, combined with the complexity of social change, determining attribution and impacts is a

very wicked problem. It is problematic given the high expectations of donors with regard to clear attribution for projects. In addition, the expectations are extremely high in relation to the timeframes in which large complex projects are implemented, and the timeframe in which they can be expected to yield outcomes.

In addition, there was discussion about links to new or existing projects – this was clearly a priority for the project. Not only was the team focusing on collaboration and synergy within the project, but beyond the project, finding linkages to research and development projects and activities.

Complexity and the review process

The review report reflects the complexity of the project. There was a significant focus on developing clear, simple take home messages about the project. This is not as straightforward as it sounds. One thing that was clear from the mid-term review meeting was that everyone saw a different view of the project – there was no one single simple take home message – each team member and group would have written it differently (which is reflected in the variety of opinions and views expressed in the interviews).

The reviewers summarised the main output of the project as farmer-truthed/tested adaptation strategies – while this makes sense, there would seem to be a lot of other interpretations of the main output which are neither more nor less valid.

A study of the documents in the project does not reveal the iterative nature and evolving approaches used in this project. Nor do the key documents (apart from a couple) reflect an integrated picture of this extensive and highly complex project, which is not surprising. This was clearly demonstrated by the confusion of the mid-term reviewers, and the patchy knowledge they were able to acquire in the fairly limited mid-term review process.

A more inclusive and flexible review process may have been better suited to this kind of complex, multi-stranded, multi-country project, but this is clearly not a procedure endorsed by the funding agency or presumably even possible for them to implement given the stringent governance requirements. This was highlighted by the project team in the final feedback session at the end of the mid-term review. Most participants voiced

a strong preference for a more engaged and less formalised review process. They also regretted the lost opportunity to have more discussion and exchange of ideas, given that this was the first time the whole team had been able to assemble in one place.

As described in Chapter 10 (constructive and creative tension), the core of the project and the research gap identified centred around a seeming paradox or dualism – that of connecting top-down and bottom-up approaches to climate adaptation, and bridging between two disparate scales and levels of reality which are household level adaptation versus policy directions.

In general, the engagement at the policy level came quite late in the project, allowing little time for dialogue and a two-way flow of information (and iterative inquiry). A number of the participants expressed concern at the time of the mid-term review that there was little remaining time to engage at the policy level, nor were they necessarily clear about what form this should take or who they should be talking to. In most cases, the project had tackled household-level crop and water management investigations early in the project, the thinking being that this would allow for an adequate number of seasons to generate sufficient data. There was no mention to me (or evidence in the papers and reports to which I have access) of steering the ongoing project design according to policy demand. This does not necessarily mean it did not happen but at the very least it indicates that this was not a dominant or particularly urgent approach or theme.

The question of scope

The reviewers made some interesting comments on what was in and out of scope. For example, the lack of emphasis on livestock, pests and diseases while at the same time a strong focus on issues of migration and labour, and the general focus on what they termed “socio-economic studies”.

This reveals some interesting disconnects and differing viewpoints. Livestock had been specifically excluded at the start at the express wish of the funding agency. So while livestock were said to play an important role in risk management and livelihoods, it was clearly out of scope for the research team.

This highlights the difficulties of dealing with a "wicked problem" like climate change adaptation. The meanings and approaches that can be attributed to this are extremely diverse and even contradictory. And the paradox of dealing with parts and wholes at the same time comes into clear focus.

This question of scope could be dealt with through boundary critique as suggested by Ulrich in his critical systems heuristics (2005). Boundary critique is intended to systematically and critically deal with questions of scope or boundary setting, acknowledging that there is likely to be significant variations in judgments about what "facts" and "values" and "system elements" are likely to be considered relevant for deciding what is "in" or "out". Ulrich proposes four basic "boundary issues": the basis of motivation, power, knowledge and legitimacy. He formulates as series of boundary questions within each of these issues (2005). This framework could also form the basis of an alternative pattern set for this particular principle of co-production of knowledge for scoping decisions.

Reflections from the project team at the mid-term review

On the last day of the review workshop, the project leader handed the microphone around to allow each team member to share some reflections on the project so far.

A common theme through many of the participants was the complexity of the project on one hand, but the flexibility of the project and the project management on the other. One team member said, "… we underestimated the complexity, the time and the difficulty in integration between the different parts of the project … but I think the project has been very good at adjusting our plans while keeping a degree of coherence".

While the participants felt there was good participation and cooperation across the different sciences, a number of team members were disappointed that there was so little opportunity to exchange knowledge and ideas across the different countries, and that this was a missed source of potential synergy.

A number of the participants also commented on potential lost synergy in coordination across the projects funded by the same donor. Given that the donor had a number of projects running in some of the countries, there was an expectation that there would be

more coordination and potential synergies.

During this session, participants also reported the need for a more qualitative approach to looking at farmer capacity and goals, and that they would have liked to spend more time investigating their perspective and strategies rather than trying to generalise up, and that a more appreciative approach to the farmers' perspective would have been helpful. In particular, there was a comment from the Indian team that the participation of women as members of farm households, farmer groups or even as representative farmers had not been included in the project.

Reflection and reflexivity in the research

The fifth principle in my transdisciplinary methodology states that iterative and developmental evaluation is only productive if there is both reflection and reflexivity, both individually and collectively. While reflection is commonplace in research and in life, reflexivity is not. Reflexivity requires self-knowledge and mindfulness and the ability to examine oneself and one's contribution in a particular situation or context (including research) and is at the core of transdisciplinary practice. However, it is not a simple matter of either reflection or reflexivity or individually or collectively. Instead there are various levels and concepts. I have used a typology or hierarchy of reflection and reflexivity to examine the types of reflection processes the research participants talked about.

The four levels of reflection in this typology, and some characteristic questions asked of oneself and the collective group are:

1. **Practical reflection**: This level is about reflection on the practical aspects of the research, data interpretation, problem-diagnosis and solution and includes questions such as: What do these results mean? What does this tell me? What are the implications? Why is this important?
2. **Instrumental reflection**: What tools or methods are appropriate to answer the research questions posed? What does validity, rigour or relevance mean here? What are the options available to answer the research questions and how effective are they?
3. **Theoretical-conceptual reflection**: What theoretical or conceptual framing

will help inform the research? Am I looking at best fit or best practice? What kind of methodological approach is helpful and appropriate?

4. **Onto-epistemological reflection**: What are my own assumptions, training, beliefs and experience? How does this affect my approach to the research? What are my biases, preferences and ethical framing and how does this compare to other participants.

Practical reflection

I recorded many instances of reflection about the practical aspects of the projects, both in the interviews and in project interactions and meetings. In the previous section, I describe the reflection session at the mid-term review in Cambodia.

Instrumental reflection

At the instrumental reflection level, many of the researchers reflected to me about their thoughts and questions about selection of tools and methods, particularly as some of them were being exposed to new approaches, tools and methods that were outside their experience. The inclusion of the livelihood analysis and the more ethnographic and inclusive approach to gaining an understanding of the farmers' viewpoints and situations was new for many of the biophysical researchers.

For example, CS3B reflected on what it would take to get a new perspective on what development means, particularly from a donor or funding agency perspective, and whether it is possible to more successfully influence the direction of particular projects. He also talked about issues of the value that is placed on certain things and areas, for example, "*I think there was an undervaluation of the water resources and the role that water resources has, both green and blue water*".

CS3B reflected on where climate adaptation sits overall in farming systems and said "*climate change is only one small driver in the whole of the decision-making process of individual farmers and communities. There are far more pressing everyday drivers that influence … So what I've been saying is, 'What you're doing is looking at opportunities to build greater resilience into the farming systems based on change that is occurring today*'."

He also reflected on the implications of weather forecasting for the project. "*Weather forecasting and … modelling … clearly indicated that the current recommendation of planting rice crops after 10 mm accumulated rainfall at the onset of the monsoon, carries considerable risk, and if you wait for 75 mm, and bring your entire soil profile up to capacity, then [the risk of crop failure] is very very low. So that's a really strong message*."

A number of the researchers reflected on these and similar issues in the climate adaptation project. In particular, some of the tensions around the paradoxes of parts and wholes (e.g. what was in scope), individuals and society (working across scales), stability and chaos (project messiness versus the need for predictable milestones etc.) and rationality and creativity (intuitive leaps and creative approaches versus tried and tested methods) stimulated considerable reflective discussion in my interviews and also in project interactions. This was much less prevalent in the poultry systems and climate-forecasting projects and may relate back to the approaches to dealing with difference, which I discuss further in Chapter 12.

Theoretical-conceptual reflection

I have very little evidence of this level of reflection or reflexivity, with one or two exceptions. Very few of the researchers in either project were aware of the theoretical or epistemological underpinnings of the research they were doing. This lack of reflection showed up in various misunderstandings and assumptions, particularly in the disconnects between biophysical research and social science.

For example, a few of the biophysical scientists expressed frustration about the social research – saying that it "*was too slow*" (that they couldn't wait for the results from this to start their field trials) and in some cases that the social scientists wouldn't able to ask the right questions, because they didn't know enough about agricultural production and technical matters. One scientist even told me that he didn't need social researchers to act as "go betweens", that he was perfectly capable of talking to the farmers himself, which completely misses the point and purpose of this kind of research.

The other area of great discomfort for the biophysical scientists was the qualitative nature of some of the social research. They could not see how such research could be

rigorous or for that matter valid. There was a strong tendency in all the projects to push everything into a quantitative frame – if there were no numbers, it couldn't be data.

Onto-epistemological reflection (or reflexivity)

One of the project leadership team demonstrated a high degree of onto-epistemological reflection or reflexivity and quite openly discussed this with me. He talked about his own journey from being a highly specialised biophysical scientist, through a series of progressions towards a more transdisciplinary approach. He freely admitted to me and the other researchers (which they recounted in their own interviews) that he often lacked in new and unfamiliar areas, and expressed a willingness to learn. He talked about his own struggle to understand the underpinnings of social anthropology and sociology, and his growing realisation that the reality of the farmers and other stakeholders was completely unlike his own.

For him, the project was an exciting journey into new fields and knowledge and understanding of the world, and he talked about these learnings with great enthusiasm. He was greatly respected and liked by his team, who were able to argue with him, and put different viewpoints without fear or discomfort. This in fact flowed through the whole team, as the level of debate, discussion and even disagreement was high, but was generally seen as safe and one of the enjoyable aspects of the project.

The various team members had very different views on how transdisciplinary the project was. This was also reflected by the very different expectations and conceptions of what transdisciplinary or integration meant, which is even further reflected in the literature. For some of the scientists, it was a huge step to go to having a social scientist take a leadership role; for others, there was still frustration that the non-disciplinary input and partnership was limited. Transdisciplinarity and what this means is highly subjective in this and many cases, and is interpreted based on the experience and background of the participant.

Summary

I have kept the findings on the these two principles (iterative inquiry and reflection) brief, as both of these are the subject of much research and commentary, and are already

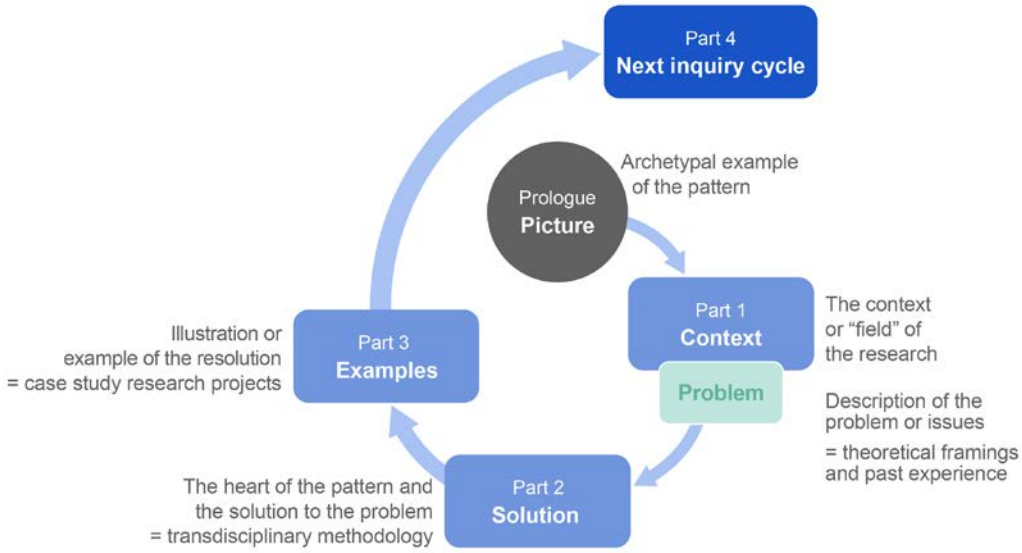
prominently featured in the transdisciplinary literature (as well as in theory synthesis in Chapter 5). However, this does not detract from their importance and centrality in constructing a relational methodology for transdisciplinarity. I discuss this further in Chapter 12.

PART 4

BEGINNING A NEW INQUIRY CYCLE

Snapshot

As outlined in my conceptual framework in Part 1, and again in the methodology in Part 3, I emphasise an iterative and recursive inquiry process. In Chapter 12, I synthesise key learnings and conclusions from the first three parts, and lay the foundation for a new cycle of inquiry in Chapter 13 – including the five steps of Alexander's pattern language, namely picture, context, problem, solution and illustration.



CHAPTER 12
SYNTHESIS OF THE INQUIRY CYCLE: TOWARDS A STRONG TRANSDISCIPLINARITY

> To produce knowledge is to accept the risk of putting to the test our beliefs and our ignorance without reducing what we do not know to what we already know and without dismissing as irrelevant what we cannot describe because we ignore it, but it is also to exercise prudence and precaution when dealing with the unknown or with the possible consequences of our action. (Santos et al., 2008)

In this thesis, I have explored the possibilities for synergy in transdisciplinary theory and practice, through the study of three projects and the researchers in those projects. Through this process I developed a methodology consisting of five principles that is designed to strengthen the practice, process and governance of transdisciplinary research. I propose a relational methodology through which (paradoxically) multiple views of reality and inquiry approaches (and their associated methodologies) can flourish and combine. This methodology provides a process by which research practitioners can embrace difference and complexity, rather than trying to reduce complexity and reach empty consensus, which itself undermines the synergies of difference.

Problem and solution: Pursuing "strong" transdisciplinary research practice

This thesis research has focused primarily on the experiences and perspectives of the key researchers and other research participants themselves, rather than focusing on project documentation and formal outputs and outcomes. This has been a very rich and rewarding source of information; reflecting viewpoints, knowledge, opportunities and approaches that are not often formally documented. These perspectives have provided a source of ideas and latent possibilities for exploiting the potential for the design and practice of transdisciplinary research. In particular, as the title of the thesis states, I aimed to explore the synergies of difference and the potential for stronger transdisciplinary research practice and governance. I explored potential for constructive approaches to tackling wicked problems through a unifying, principles-based

methodology. This methodology is informed by, and documents, the existing "strong" transdisciplinary practice among research teams in the case studies, as well as highlighting ongoing challenges. The principles and associated pattern sets are used to analyse the data at the same time as the data tests the principles.

Sarewitz warns that "growth of disciplinary scientific methods and bodies of knowledge results in an increasing disunity that translates into a multitude of different yet equally legitimate scientific lenses for understanding and interpreting nature, and that all humans have only partial understandings of our world on which to make decisions" (2004, p. 390). This growth in disciplines and their depth of knowledge is crucial to advance knowledge, but the lack of connection and synergy between the disciplines is highly problematic. In addition, the lack of inclusion of non-disciplinary (non-research-based or practitioner-based), experiential knowledge is a critical omission.

I have adapted Max-Neef's concept of "strong" and "weak" transdisciplinarity, where he states that "an integrating synthesis is not achieved through the accumulation of different brains", but instead requires us to "break with the assumption of a single reality" (2005, p. 5). However, "strong" transdisciplinarity is still in the making, and an ongoing project (Max-Neef, 2005). To truly transform transdisciplinary research practice requires iterative, ongoing and collective learning.

In this thesis, I posed the following Research Questions:

1. What frameworks and concepts may be useful to facilitate more effective transdisciplinary practice that enables synergies to emerge from difference?
2. How do researchers experience their own transdisciplinary practice in tackling wicked problems?
3. Can there be a unifying, connecting and effective methodology for strengthening transdisciplinary research practice?

I address Research Question 1 in Part 1, where I explore the literature to identify frameworks and concepts that can contribute to building stronger transdisciplinary practice. In Part 3, I test these frameworks and concepts and address research question 1, through the study of the three case study research projects. I document the research practice, experiences and perspectives of the researchers in these three teams. I do this

by applying and testing an emergent methodology in five principles for transdisciplinary research inquiry and practice, which I outline in Part 2. I provide a synthesis, conclusions and implications here in Part 4.

Synergy on the "edge of chaos": a relational methodology

My primary conclusion is that an overarching or relational methodology is not only possible, but is needed for "strong" transdisciplinary research practice, process and governance. I have demonstrated this by developing and testing such a methodology, which has emerged from my own study of the case study projects and the theory and literature, which informed each other recursively. In this sense, I am describing a methodology as a set of underlying principles, rules and ways of thinking (in this case summarised as five principles) which are based on a pattern language – using a series of pattern "sets". I emphasise that this methodology is (paradoxically) about coherence, connection and synergy without restricting the richness and difference associated with differing world-views, including various disciplines, and the many other practitioner world-views and experiential knowledge.

An overarching and relational methodology is critical for effective transdisciplinary research, to provide connection and synergy between the different disciplines and other world-views that come together to solve problems. At the same time, such a methodology provides space and opportunity for different perspectives, world-views, theories, methodologies and methods to co-exist. Although methodology is generally seen to emerge from the nature of particular disciplines and perspectives (Lincoln et al., 1994), I suggest that it is possible and helpful to have an overarching methodology, while leaving the door open for diverse disciplinary methodologies to co-exist.

As outlined previously, I define synergy as "the effect, greater than the sum of the parts, that comes from the combined forces of a number of forces, mechanisms, etc." (Australian Macquarie Dictionary). I use the term synergy here to denote a coherent (and connected) set of parts making up a whole that is greater than, **and different from**, the sum of the parts. The methodology aims to provide a foundation and a set of principles to allow for difference to flourish. This includes more systematic and equitable inclusion of non-researcher, practical and experiential knowledge, preventing more powerful disciplines or worldviews from dominating at the expense of others.

Difference is key here, and is essential to create a broad and inclusive picture in, and of, a self-organising system. No one researcher or participant can hold all such information in their mind, nor can one line of inquiry yield the breadth and diversity of solutions that are required for wicked problems (as described in Chapter 3). It is only through collective endeavour – bringing together many and different minds.

This process of finding synergy between different world-views and approaches aligns with Checkland's concept of constructing a learning system that can be used to view and navigate complexity (2012, p. 142). This leads on to the concept of self-organising systems (which I describe in Chapter 3), which have characteristics such as emergence, non-linear dynamics, internal diversity, perturbation and feedback loops. The nature of the system and its elements and relationships emerge recursively for continuous change and self-organisation (Fenwick, 2012).

Here I return to the concept of the border between order and chaos, which Ramalingam describes as "the edge of chaos" (2013). I suggest that a self-organising system is a useful metaphor for a "strong" transdisciplinary research endeavour. While a research process is in one sense an ordered, organised process, research into complex phenomena is itself a complex adaptive system, and "all complex adaptive systems … evolve to a natural state between order and chaos, a grand compromise between structure and surprise" (Kauffman in Ramalingam, 2013, p. 146).

The third case study is a useful example of this. On one hand, the project was highly organised and ordered, with detailed plans, log frames, spreadsheets, role descriptions etc. On the other hand, the characteristics of Case Study 3 included highly dynamic relationships, emergent ideas (e.g. livelihood trajectories), internal diversity, messiness, continuous learning and reflection within the team, and evolving ideas and approaches. Tension and conflict were not suppressed, but rather were treated as a constructive part of the research process and engagement.

The Case Study 3 team was more able to deal with such tensions and conflicts and the complexity of the research context because they felt secure enough to step out of their comfort zones and take a level of risk because (in the words of Alexander) they were engaging from a perspective of "safety, comfort and a good view". Alexander uses this phrase to describe what humans seek in their living environment. In this case, in a

transdisciplinary research project, “safety” (rather than being physically safe) refers to the feeling of being valued, having a clear role and set of responsibilities, and feeling their position in the team (and their job) to be relatively secure. “Comfort” in this case could refer to a number of things, including enjoyment of the research process and the team, and a sense of satisfaction about the work they do and the progress they make. The “good view” I interpreted as being able to see and understand the processes in the project, that the management and governance of the project is clear and transparent, and that the outcomes and progress of the project are shared.

The case studies confirm that creating a safe and comfortable space with good visibility and transparency of the activities and process of the project is likely to mean a more creative, productive and empowered team. This requires an open and confident approach by the project leadership and includes a willingness to take risks (for example trying new, innovative approaches). Given the competitive nature of research, and the stiff competition for research funding, this can come at considerable cost.

“Safety, comfort and a good view” also applies to the funding agencies and donor participants in the project. Unless donors and their agents have a sense of safety (that they are not taking undue risks with taxpayers’ or donors’ money), some comfort with the approach and proposed outcomes, and a good view and understanding of the context and processes within the project, the funding pipeline is likely to develop blockages.

A pattern language and pattern sets

The second major conclusion is that a pattern language approach as described by Alexander (1977) shows potential to support and operationalise the five principles of the proposed strong transdisciplinary methodology, to provide a common framing to bring together different worldviews, knowledge cultures and mental models. By adopting a pattern language with provisionally universal pattern sets, there is the possibility of synergy for a much richer and more productive understanding of our world and the problems we tackle, through which to make decisions and resolve problems. I use the term “pattern” to denote an element that repeats in a predictable manner, or which is in some shape or form regular, and that “formalising and quantifying the notion of pattern and the process of pattern discovery go right to the heart of scientific practice” (Crutchfield, 2003, p. 31).

The pattern sets I have developed and tested in the thesis are provisionally universal (i.e. intended to have broad application across diverse transdisciplinary contexts). I do not suggest that these are the only pattern sets possible, but I do suggest that these particular pattern sets can adequately function as universal tools in the design and implementation of transdisciplinary research and its practice. In this thesis, the principles and associated pattern sets have been applied as a retrospective set of lenses to the case studies. The next step is to apply and test the principles and pattern sets for design analysis and implementation of projects.

Five principles for transdisciplinary practice: emergence and function

The five principles and their associated pattern sets, which together form the methodology, emerged and were tested as analytical tools on the data from the three case studies. The function of the five principles is to enable conversation, collaboration, review and analysis of transdisciplinary research practice and governance. They offer an entry into the "black box" of highly complex transdisciplinary projects.

Principle 1: A collective inclusive approach to appreciative, context-based problem-framing is needed to embrace the richness of complexity

The principle of appreciative context-based problem framing highlights the need to take a more inclusive and appreciative look at the kind of research problems we are tackling and the context of these problems. This is not easy to do. For example, funding for such projects generally comes with a donor expectation attached about the nature of the problem, the approach and the relative importance. This is not to say that this view is incorrect – the donor perspective, with all the policy and political knowledge and context it brings is crucial. However, it is not the whole story.

An inclusive approach to problem framing needs to embrace complexity (rather than reducing it) to open up access to a fuller range of perspectives, options and solutions. The appreciative aspect is critical as it removes normativity or judgment about the different perspectives. As outlined in Chapter 3, the focus here is on wicked problems as defined by Rittel and Weber where the "formulation of a wicked problem is the problem!" (1973, p. 161).

The pattern set I use to demonstrate and operationalise this principle is an adaptation of Ashhurst's six dimensions of wicked problems, and a synthesis of the characteristics of wicked problems from the wicked problems literature (2014). Based on the analysis and issues emerging in Chapter 8, I have summarised the six dimensions and a brief description as follows:

1. Diversity (number and variety of stakeholders, world views, knowledge cultures etc.)
2. Intractability ((in)flexibility, (un)predictability, adaptability/rigidity)
3. Complexity (consisting of many parts)
4. Ambiguity (vagueness, contradictory meanings, uncertainty)
5. Instability (subject to change)
6. Confounding factors (anything that restricts, limits or opposes actions or alternatives).

From the analysis, the six dimensions show potential as an analytical and dialogical tool or heuristic at the project scoping and design stage, to explore and document the context of wicked problems in complex systems to bring together the diversity of perspectives, worldviews and paradigms. In addition, they should also be used during the life of the project (at the various review and reflection points) to re-examine the context and problem during the life of the project (given that instability is one of the characteristics). It can also be used as a tool in mediating and addressing power imbalances, where one discipline or world-view may hold greater sway than another.

The value of greater contextualisation of problem/solution focus in wicked problems in complex systems has three main strands. Firstly, the effort required to develop an understanding of the research context in a complex transdisciplinary project is frequently underestimated. If insufficient time and resources are allocated to the investigation of this, many potential sources of valuable knowledge about the context may be overlooked.

Secondly, problem identification cannot be adequately done until there is a clear and shared understanding of the context. One of the traps in project scoping is the tendency to default to familiar or fashionable problem framings, which are often strongly influenced by the dominant discourse or the policy "trend" of the day. In addition, the

danger of leaving contextualisation and problem identification to one discipline or worldview, means (as the cliché goes) if all you have is a hammer, everything is a nail. If your expertise is in crop modelling, then it is likely you will see a crop model as at least part of the solution. Thirdly, the process of pulling this information together is challenging, particularly when you are inevitably going to have seemingly incompatible and at the very least variable views and knowledge.

The findings presented in Chapter 8 are a demonstration and a test of a more constructive approach to coming to grips with the context. The main lesson I draw from this analysis is that the boundaries around the research context need to be broader and more permeable, and the "arena" for participation in research and its practice needs to be wider and more inclusive. This does not mean that research projects need to become ever larger, but rather that the context that they draw on is more inclusive of the various layers of complexity and informed by the different systems that they inhabit. There are two broad areas where this needs to be considered.

Firstly, there is the matter of what is "in" the research or "out". For example, in Case Study 3, there was much debate about whether livestock should be part of the research into climate adaptation strategies for smallholders. Rather than debate this, I would suggest that livestock are "in" the system, and the production of them a key adaptation tool whether it suits the research or not. Whether or not there is a research focus on this, the place of livestock in the livelihoods system cannot be ignored or set aside. The second area is the research process and practice itself. As a researcher, one is never "outside the system" and must inevitably and inadvertently change and influence that system. The implication of this is that researchers should consider themselves, their practice, and the constraints and opportunities they face as a part of the research context.

Principle 2: Co-production of knowledge across the boundaries of knowledge cultures and worldviews requires an inclusive, shared language for human and social inquiry

Once the context and the problem have been explored collectively, co-production of knowledge and a collective, transdisciplinary inquiry approach is the next challenge. By

co-production, I mean the collaborative production of knowledge that not only transcends disciplinary boundaries, but also between science and non-science knowledge groups (Pohl et al., 2010; Polk, 2015).

The pattern set I have adopted for this principle, is the five doorways to understanding (which I also call lenses on the "*Lebenswelt*", or lifeworld) which are adapted from Brown and Harris' (2014) seven questions and Hocking et al.'s (2015) doorways to understanding. The subset of five doorways to understanding that I use here, provide a set of patterns to navigate between different worldviews. The five doorways or lenses are:

- Physical: The lens or doorway is to do with the material world.
- Social: This lens generates questions and understandings through the lived experience of the community and individuals.
- Ethical: This doorway includes ideals, principles, aims and standards of good and bad. It underpins our social networks, informing social rules and standards and is about the ways in which humans interrelate.
- Aesthetic: This lens includes designs, perceptions, visions, and concepts of beauty and ugliness, and goes to the heart of human creativity. It is about how each of us perceives the world subjectively.
- Sympathetic: This lens is about relationships and relating, and can only be explained through connections to other people or beings or things. This includes concepts such as trust, relationships, sense of others, leadership, conflict, friendship etc.

From the preceding interpretation (analysis), the five doorways or lenses to understanding show promise to be a potential tool for exploring tacit, unknown or invisible aspects of transdisciplinary inquiry, and for bringing together the widely varying knowledge and viewpoints of participants (both researcher and non-researcher) in a more effective and collective way. The five doorways provide a non-disciplinary and non-exclusive way in which to discuss and map out questions, issues and inquiry processes. Each of these ways of knowing provides a way to generate sets of questions and pick up on some of the issues that are missed by disciplinary-based inquiry. Following on from this, these ways of knowing provide a guide to the kind of evidence

and information that needs to be gathered.

For example, in Case Study 1 (see Chapter 7), there was a disconnect between the traditional farmer knowledge and understanding of climate and climate forecasting, and the scientific endeavours of the scientists in the project. While each group is most likely generating useful and actionable knowledge there appeared to be very limited scope for each group to communicate effectively within the project and co-produce a synergistic outcome.

Similarly, in Case Study 2 (Chapter 7), the veterinary and public health researchers struggled to find common ground, despite (and perhaps because of) the similarities in their disciplines. By removing the partisanship of the different language, practice and epistemology of each of these groups through a third approach, these barriers and tensions may be more easily navigated and exploited.

In Case Study 3 (Chapter 9), different approaches, solution sets, research methods and timelines between crop and social scientists (where world-views are fundamentally different) created various disjuncts and misunderstandings (some of which were resolved). In addition, there was ongoing debate and reframing around the donor focus and the reality at the local, household and village level. Policy changes and focus at the donor level may not necessarily reflect the everyday reality at the local level, nor can it reflect the heterogeneity at the local level.

In all three case studies, connecting (and cross-informing) research outcomes and evidence with policy framings and direction was a considerable challenge. The ethical doorway to understanding, in particular, provided some useful insights to connect the priorities and beliefs of various stakeholders (from rice farmers through to national governments) and to highlight differences and disconnects. All three projects included policy outcomes, but the pathway to engage with policy stakeholders was not particularly clear. I discuss this further in Chapter 13.

A good example is exploring the ethical doorway or way of knowing to highlight issues around policy perspective and policy engagement. My findings suggest that had the inquiry process and development of research questions explored the ethical lens or perspective, policy perspectives could have surfaced and been discussed much earlier in

the project and the necessary expertise could have been sourced. Instead, the project focused on policy engagement at a late stage of the project. This not only left the researchers very little time to act on this, it also meant that the project was not guided and informed by these various perspectives in the early stages.

I emphasise that this pattern set of inquiry lenses or doorways does NOT replace disciplinary inquiry, methods and analyses, nor does it align with them, but should instead transcend and connect them, and help create an overarching, relational framework within which to make decisions about specific methods and to create synergies between them.

Furthermore, the answers or solutions to key problems and questions should not be reduced to simple unified answers, by erasing or homogenising geographical, cultural and other differences in worldview. Hulme very clearly outlines the dangers of this in his exploration of the globalization of climate knowledge and that a "homogenized understanding of climate change 'detaches global fact from local value, projecting a new totalising image of the world as it is … It therefore destabilises knowledge at the same time that it seeks to stabilise it'" (Jasanoff, 2010, p. 236 in Hulme, 2010, p. 561). I use this example to warn against using a collective approach to obtain a homogeneous answer or solution – rather I suggest that the answers to research problems in transdisciplinary research will be heterogeneous and multiple. This has implications for the processes of "scaling up" and "out-scaling" which are common in international development research and implementation, which I discuss in the next chapter.

While data gathering will continue to be carried out using the tools developed through the various disciplines, the identification of research questions and the prioritisation of evidence and findings (as well as the choice of methods) can be enhanced and enriched. This also provides a common set of questions for the various disciplinary and non-disciplinary participants and creates inclusiveness, rather than ring-fencing knowledge into disciplinary groupings. I give an example of the application of the doorways to understanding in Box 1.

These ways of knowing also recognise that inquiry processes are fundamentally human – i.e. that inquiry is a process all humans engage in, in similarly human ways. This does not make disciplinary expertise irrelevant, but it calls into question the assumption that

disciplinary knowledge is "better" or "more correct" than practical and experiential knowledge, and discussions about one discipline being "better" or "more scientific" than another.

This is not to say that these five are the only possible options – they are an example tool to demonstrate the importance of co-production of knowledge and "strong transdisciplinarity" as described by Max-Neef, to create a coherent, rich and articulate story, drawing in different realities and system views.

Box 1: *Har thit thang* "five directions"

I participated in a workshop in Lao PDR while writing up my thesis, where I used the five doorways as a tool and pattern set to assist a group of district agricultural extension staff to explore and make explicit what they already knew and what they needed to know to work with farmers on implementing new technologies and techniques for improving agricultural production. The Lao participants translated the five doorways to the Laos language "*har thit thang*" which means "five directions". I combined the "five directions" as the team called them with a representation of three different system levels (paddy, household and community) to help them to think more broadly about the factors that would influence uptake of new technology and livelihood improvement, and to place these technologies in a broader social context.

The five directions were enthusiastically discussed and used, and provided a means by which the extension officers (who had variable levels of education and understanding of the kind of language and ideas expressed by the researchers not to mention limited English comprehension) to communicate clearly across the knowledge boundaries and to express their practical and local knowledge about the farmers they worked with in a way that could be shared and discussed with the workshop stakeholders. At the time of writing, a further stage of discussion around the "five directions" is planned at the district/community level and including the farm household members themselves.

The five doorways also highlighted the challenges of distinguishing between the social and the physical, and the fundamentally entwined nature of the two. Because of our extensive use of metaphor and the blurred boundaries between the social and the

material, the distinction between social and physical is not only blurred, it can be misleading, without being particularly helpful. It is useful however, to highlight that much of what we regard as physical evidence in research includes much assumed knowledge as well as social agreement. Latour and Woolgar (1986) give excellent examples of this in the laboratory, where interpretation of the results of a chemistry experiment rely heavily on prior knowledge and the shared understanding between the scientists in that particular "Denkkollectiv" (thought collective) or community of practice of what this actually means. The danger lies in the invisibility of the social construction of a physical phenomenon, which closes off other potential interpretations, or the possibility that the current understanding may be wrong or inaccurate or simply not useful.

In addition, there is a tendency to focus exclusively on the physical and social, at the expense of the other three. Therefore, bringing forward the ethical, aesthetic and sympathetic ways of knowing and making them explicit and visible is critical. This can be used as a means to steer the researcher away from the trap of a false social-physical dichotomy, though I suggest that the ethical, aesthetic and sympathetic can be regarded as subsets of the social way of knowing and are essentially about social interaction and relationships at a number of levels.

Climate adaptation (which was a focus for two of the three case studies) is a very good example. All five of the doorways are invoked in the participants' accounts of the projects, though very little of this appears in the project documentation. This is not to say the ethical, sympathetic or aesthetic doorways have not been documented in other work. In fact, they predominate in the humanities, and humanistic interpretation and analysis, anthropological, design and other disciplinary studies. Roncoli et al. (2008) provide a great example of an anthropological view of climate change and the importance of seeing through all the doorways, describing the importance of the impact of change in climatic conditions and resultant landscape changes having a significant impact on people's sense of well-being and harmony (the aesthetic). They go on to say the "personification of landscape features reflects a view that nature includes humanity and culture rather than being juxtaposed to them" (the sympathetic) (Roncoli et al., 2008, p. 93).

The point here is not that we all need anthropological training to gain an understanding

of the impact of climate change. The point is to find a way to make the knowledge inherent in anthropology, sociology, agronomy, climate science, meteorology (and so on through the disciplines and non-disciplines) accessible, and able to be shared for coproduction of a more holistic and systems-based view of problem solving and research investigations.

This view also allows for non-disciplinary knowledge to be constructively brought into the co-production process. In each of the projects, engaging effectively with the non-disciplinary participants was challenging. In the climate-forecasting project, the project team had to rely on a quantitative baseline survey delivered by a set of locally-based enumerators whom most of the team never met. From this survey, they were expected to understand the needs, perspectives and preferences of the local farming community. Firstly, as the findings demonstrate, these farming communities are highly heterogeneous and exercise preferences, assumptions and priorities in highly individualistic and situational ways. Secondly, these farming participants or beneficiaries as they were often called have significant pertinent knowledge to contribute to the co-production.

The key example of this was the range of local forecasting knowledge that the farming communities (and many of the researchers who worked with them) in both India and Sri Lanka recounted to us. The missed opportunity here was to bring together and investigate this local knowledge alongside the scientific climate modeling for a rich tapestry of knowledge which could potentially have yielded not only some novel solutions, but also helped to bring the somewhat alien scientific forecasting knowledge into the context of the local population.

Principle 3: Working constructively with tension is a catalyst and foundation for transformational learning and change

Principle 3 goes to the nub of the challenge of co-production. The issues created by different forms of tension and conflict, which I outline in Chapter 6 (including dichotomies, dualisms, pattern conflicts and paradoxes), are documented in the findings, particularly in Chapter 10.

The pattern set adopted to operationalise this principle is the four “sets” of paradoxes

(adapted from Brown & Harris, 2014) that I use to group occurrences of the above as outlined in Chapter 6. These are:

- Parts and wholes
- Individuals and society
- Stability and chaos
- Creativity and rationality.

Bringing together seemingly conflicting knowledge and approaches creates tension, which can either be exploited for novel solutions and innovation, or treated as a negative event. The thesis findings provide examples of both responses. In some cases, these tensions were seen as opportunities for new thinking and in others they were avoided or ignored.

Parts and wholes

One of the key stumbling blocks for transdisciplinary complex systems research into wicked problems is the need to reconcile parts and wholes. By necessity, no research approach or design can encompass an entire system, particularly as the boundaries of most systems are likely to be contested or at least varied depending on who is defining them and why. In addition, the literature on wicked problems clearly states that there are only partial and ongoing solutions rather than one final solution. A single project, no matter how large, will not suffice.

Nor can it focus on a part without considering the context of the whole (or various wholes). By contextualising the "slice" or part of the system that is the subject of the research study as part of a series (not just one) of larger "wholes" or systems, the research can be more grounded in the wider realities of the socio-material systems in question. For example, in Case Study 3, there was concern and debate about the pros and cons of including livestock management into the research. On one hand, the project was already sufficiently large and complex; on the other hand livestock plays a crucial role in household system management and could potentially play a more important part.

I argue that, rather than further complicating and enlarging the project and creating a higher risk profile (and a less happy donor), the project could be more effectively contextualised. To achieve this, there are a number of options. Firstly, a more concerted

effort to connect up with associated and complementary projects (such as livestock management), secondly being flexible and pluralistic about the levels and composition of systems (be it household, village, district, value chain and so on), and thirdly taking an integrative approach throughout the life of the project, including acknowledging multiple perspectives, objectives, and approaches. For example, a household livelihood analysis needs to include a systemic view of sources of livelihood, even if this includes aspects such as livestock production that may not be investigated in this particular project.

So rather than creating larger and more unwieldy projects to take a "systems" approach, why not instead focus more on cross-project collaboration and linkage, and promoting continuity from project to successive project? While two of the three project teams spent considerable time linking to other stakeholders and activities, this was seen as an add-on, or implementation-based activity, rather than an integral part of the research activity in itself.

Post-positivist science teaches us that we can either focus down to exclude elements, isolate variables, and know more and more about less and less; or we can focus on an all-encompassing systems approach. Instead, we should be able to do both. Conversely, trying to focus on prediction and system control in organised complexity systems as defined by Warren Weaver (in Ramalingam, 2013) is likely to be at best fruitless, and at worst highly destructive and a return to the kind of projects of high modernity and social engineering. By accepting a more organic approach and understanding the relationship between parts and wholes as a productive tension, this allows for what Ansell calls a "mediating relationship" between two extremes. Focusing on both parts and wholes allows for an analytical approach (breaking up complex problems into smaller and related parts) at the same time as considering the whole as the context (Ansell, 2011).

Individuals and society

Similarly, the paradox of individual and society also informs transdisciplinary research in that it is impossible to consider the individual without seeing them as part of society, or of society as made up of individuals. A key issue that this paradox highlights is the problem of what is described in research and development as "scaling up" and "out-

scaling". In one sense, Case Study 3 addressed this challenge through the household typology approach, addressing the heterogeneity at the individual and household level, but at the same time providing an intelligible set of typologies for national policy-level engagement, though there is no evidence available on which to base an assessment of how effective this was.

However, the reality of scaling up or out-scaling a particular solution or intervention from a particular system to a broader range of systems is that it rarely works, as each system and situation is unique and complex. What works in one village in Africa may or may not work in another village, and is probably going to need considerable adaptation, if not a different approach, to translate it to a solution in a village in Cambodia. This is well articulated in a recent article by Michael Hobbes in *New Republic* where he describes "Exciting new development idea, huge impact in one location, influx of donor dollars, quick expansion and failure" using the example of PlayPump – a merry-go-round hooked up to a water pump and a storage tank in sub-Saharan Africa (2014, p. 2).

Each of the case study projects tried to address the individuals and society paradox in different ways. The adaptation project focused on farm household typologies, focusing on indicators that were relevant across a wider range of situations. The poultry-cropping project focused on longevity and continuity of activities to allow for adaptation and reframing of solutions for different situations. The first case study (climate forecasting) faced the most challenges with this, as they tried to aggregate up household information to try to create a broad picture across the dry zone of Sri Lanka. In this case, the focus was generalisation rather than allowing for heterogeneity.

Stability and chaos

The challenge here is working with messiness as an inevitable part of dealing with wicked problems and complex systems. Crutchfield (2003) talks about the "dynamic interplay of order and chaos" and describes this space as being the source of human innovation, which counters the common belief that the process of innovation can be ordered and linear. In transdisciplinary research practice (discussed in chapter 4), a focus on complexity and its concepts has been shown to assist participants not to prioritise consensus and agreement, but rather to seek and engage with greater diversity in the research system that they are part of (Fenwick, 2012).

While diversity lays open a wider range of options and avenues for constructive change and even transformation, it is anything but tidy and linear. The project leader in Case Study 3 took a dual approach – combining a highly structured approach to budgeting and log framing, but also allowing for messiness and emergence in the conduct of the project. This required a high level of trust between project leader and team (and vice versa) as well as tolerance of ambiguity and change.

Creativity and rationality

The juxtaposition of creativity and rationality encompasses a range of dualistic descriptions including gestalt versus logical thinking, concrete experience versus abstract rationality, qualitative versus quantitative inquiry, subjective versus objective, and intuitive leaps versus stepwise analysis.

Transdisciplinary research has the potential to create a powerful harnessing of these seeming opposites, with practical and local knowledge and experience brought together with rational scientific approaches. In Case Study 1, there appeared to be no opportunity to bring together the deep, multigenerational, practical experience of an ancient farming culture, with the deep and sophisticated knowledge generation of the climate scientists. Alternatively, case studies two and three were able to some extent to harness these differences, and demonstrate that it is possible. In Case Study 3, the tensions and conflicts even within the research disciplines were expressed, and the resulting conflict allowed for more systemic and innovative discussions among the team members.

Principle 4: An iterative or recursive research inquiry process is essential for transformational learning, and for theory and practice to constructively inform each other

The process of reviewing complex research for development projects is always tricky and there are various approaches to this, and to monitoring and evaluation more generally. I am not attempting to address this issue in detail or to review the voluminous literature on this subject. However, it is a key element in the transdisciplinary methodology, as part of the recursive nature of inquiry in complex systems.

I discuss here the need for iterative process, governance and reflective and reflexive

learning. The donor for two out of three of the projects (case studies 1 and 2) has a well-documented and well-laid out process for reviewing projects at mid-term and at full-term. This involves external reviewers, measurement against set milestones in the project plan, and measuring the extent to which project objectives have been met. Budget expenditure is also examined against the backdrop of achievements to date. The reviewers also look at impacts current and potential.

This does not take into account the wicked problem component, where the situation is constantly changing, there are no final solutions but a series of partial ongoing solutions, and where research questions and objectives need adjustment through the life of the project (though some adjustment is possible). Nor does it allow for the rich contribution of the highly diverse stakeholder knowledge, or for synergies to emerge from access to all the ways of understanding.

The mid-term review of the climate adaptation project (see Chapter 11) reveals some of the challenges of this approach. With such a detailed and complex project, trying to be comprehensive and inclusive of the vast array of activities and research outputs was counteracting efforts to take a holistic view of the project. Given how productive and prolific the research teams had been, the reviewers were overwhelmed with information and some of the key strands were lost in the detail.

Added to this was the frustration expressed by some of the participants who did not have the time and resources to make the most of being together in one place to problem solve, exchange ideas, modify approaches and integrate their work for a more holistic bigger picture view. Instead they crammed as much activity as they could into every available moment, including lunch, tea breaks, evenings, nights and the field trip. The review meeting was meant to be an opportunity for planning the second half of the project, but there was relatively little time allowed for this activity, and many participants expressed disappointment about this.

The mid-term review in Case Study 3 highlighted an opportunity for a more developmental evaluation-based approach, combining summative (assessing what has already been done) and formative (using learnings to form and revisit the design and approach for the remainder of the project). The strong focus on documentation and accountability in the mid-term review did not allow the team members the time and

opportunity they felt was necessary to share their learnings and apply them for design and planning for the second half of the project.

Many of the researchers in this project talked about the project as a personal and collective learning journey, reflecting a view of research as a process of continuous learning. This could be much more effectively acknowledged and acted on in project design and governance, which I will discuss further in Chapter 13. But it is unrealistic to believe that we can achieve this with a linear approach to inquiry design. Only by examining, reexamining and questioning our approaches, can we hope to make progress with these seemingly intransigent sources of tension. Only in this way can we hope to truly learn and transform.

The inquiry process of this thesis is a demonstration of the possibilities of this iterative approach to inquiry. I adopted a combination of the adaptive research approach of Layder (2005) with the pattern language process of Alexander (1977), which I describe in the conceptual framework in Chapter 2. This combined approach includes iteration, a focus on pattern identification and discovery, theory and data iteratively informing each other, which I argue is well suited to inquiry into wicked problems in complex systems. It also allows a more open and flexible approach where multiple disciplines and worldviews are present, all of which have their own methodologies and inquiry approaches.

Alexander's five steps of picture, context, problem, solution and illustration are combined with Layder's cycling between theory and data which inform each other. My own inquiry process began with the problems of co-production and multiple world-views in research for rural development. Using this approach I was able to use a series of three case studies interspersed with exploration of theory and existing practice to gradually focus or expand my inquiry and identify a principles-based methodology and pattern sets. In the next chapter, I return to the beginning of the cycle to re-examine the context and explore the next generation of problems that this inquiry exposes.

Principle 5: Reflection and reflexivity (both habitual and systemic) are essential to enable the researcher to constructively capture transformational knowledge co-production

An effective iterative approach, as described in the previous principle, requires reflection and reflexivity to capture transformational knowledge and learning. But reflecting on approaches and inquiry is not enough. Only when we are able to question and examine our own ways of knowing and understanding the world (both individually and collectively) can we hope to be able to embrace new thinking. This is reflexivity. And it is difficult.

What is effectively happening in transdisciplinary research, in bringing together different worldviews and approaches, is the combination of very different onto-epistemological framings (as outlined in principle number 5). To understand this, requires the highest level of reflection, or reflexivity, where the reflexive individual or group ask the following questions of themselves: "What are my own assumptions, training, beliefs and experience? How does this affect my approach to the research? What are my biases, preferences and ethical framing and how does this compare to other participants?"

The ability to be reflexive in the deepest and personal sense is central to the methodology outlined in this thesis. It is clear from the findings that there was a significant disparity between the various researchers' ability to be deeply reflexive in the context of the research. Given the focus on objectivity that is such a strong feature of post-positivist science, building this skill may require training and a broader grounding in the philosophical foundations of the various approaches to science. The findings in Chapter 11 demonstrate that there are very varied levels of reflection (based on the hierarchy or typology from Salas-Zapata), but reflexivity – the deepest form of reflection was sparse though present in the data I collected from each of these projects.

Lack of visibility of these areas for reflection and reflexivity is a make or break for transdisciplinary research. Without this ability to look at the critical and transformational aspects of the research and to question the values, ideologies and power structures that shape research (Popa et al., 2014), the possibilities for truly new thinking and approaches are limited. This includes the need to understand and

contextualise institutional settings which frame research design and flow through the whole process and practice of research. Without this depth of reflexivity and the questioning of the tacit or unacknowledged, the latent potential and depth of transdisciplinary inquiry, and the possibilities for moving beyond our current practice cannot be fully explored.

Conclusion

The five principles do not operate in isolation. There is significant overlap and dependency between them, as outlined above. The five principles offer the potential to enable conversation, review and analysis of research practice, and a way to navigate the contradictions, complexity and dissonances of transdisciplinary research to enhance the quality, effectiveness and efficiency of research, and transition more consistently to "strong" transdisciplinary research practice, process and governance.

CHAPTER 13
BEGINNING A NEW CYCLE OF INQUIRY: EVOLVING CONTEXT AND PROBLEMS

> In essence, every solution to a wicked problem is another wicked problem.
> (Michael Batty, 2007)

In this chapter, I flag the beginning of a new cycle of inquiry, starting with the picture of an ongoing spiral of inquiry process (Figure 7). I look at an evolving and broader context for transdisciplinary research practice, and look at the new set of problems and challenges that have emerged from the thesis inquiry cycle.

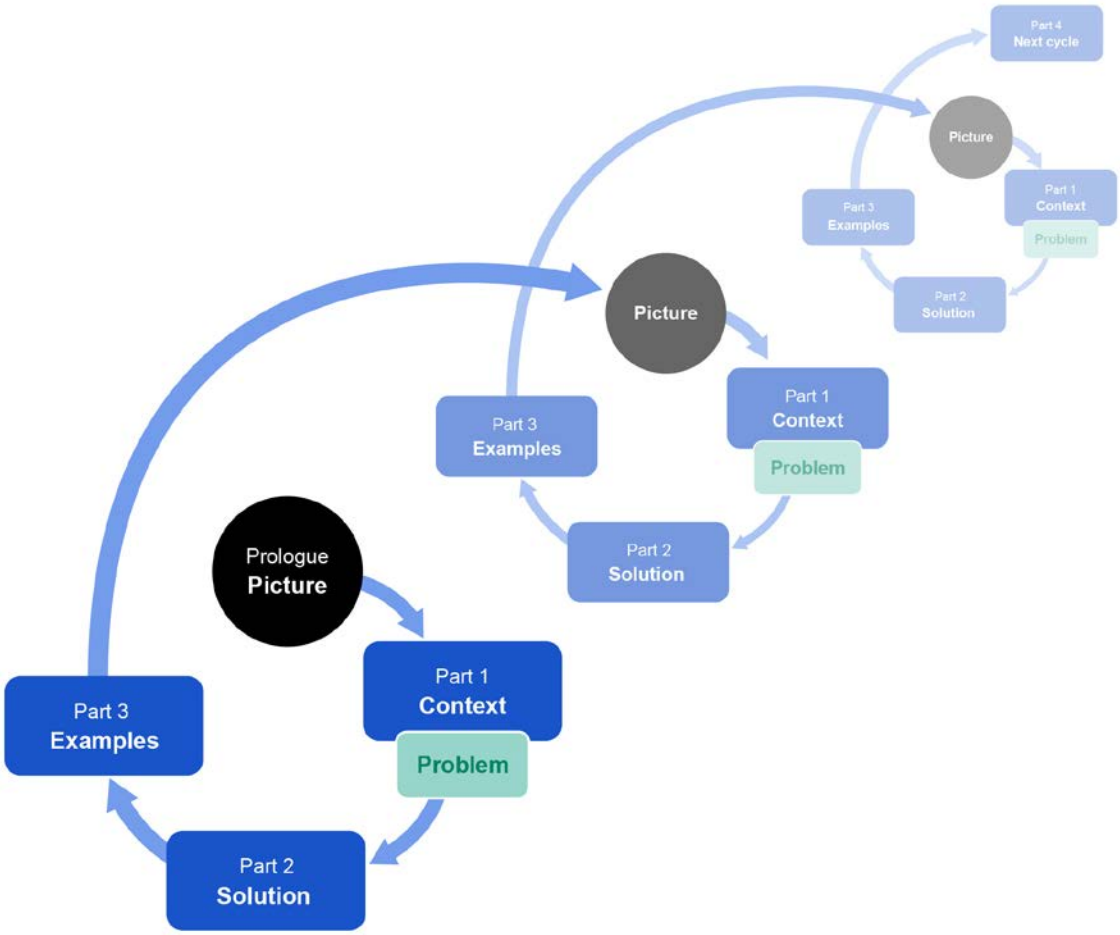


Figure 7: A new picture – ongoing inquiry cycles

Picture

As the thesis inquiry cycle ends, a new cycle begins. This is crucial, since "wicked problems have no stopping rule" (Rittel & Weber, 1973, p. 162), and for every solution there is a new problem and "every wicked problem can be considered to be a symptom of another problem" (Rittel & Weber, 1973, p. 165).

And each new cycle begins with a picture. The thesis picture was driving in Syria – exploring the seeming dichotomies and paradoxes of a self-organising system, and the "edge of chaos" (Ramalingam, 2013). For the next cycle of inquiry, one that includes the synergistic methodology, there is an evolved context, a new set of questions and problems, a resolution and a need for evolved practice. Here, the picture is that of a seemingly endless spiral of inquiry and endeavour stretching across time and space. This spiral (based on the pattern language of Alexander et al., (1977) and Layder (2005) forms the basis of an inquiry process to implement the transdisciplinary methodology synthesised in this thesis.

An evolving context

The thesis context (as outlined in Part 1) was international research for rural development, which was the background for the case study projects, and for much of my own experience. Through the inquiry process in this thesis, this context has widened to the broader suite of wicked problems in complex systems including what is described as sustainability science, complex systems science, the broader field of transdisciplinary inquiry and collective and evolutionary learning. This inquiry process and its solutions have highlighted a new and emergent set of challenges in the broader context of research to tackle wicked problems through transdisciplinary practice, which can include endeavours which are described as sustainability science, complex systems science, transdisciplinary research and so on. Just as the context has shifted and broadened, so also the problem has evolved.

An emergent problem set: enabling transdisciplinary research

The synthesis in the previous chapter summarises the significance of the overarching relational transdisciplinary methodology. The purpose of the methodology is to provide

a set of meta-principles and the pattern sets (tools) to deal with the set of more specific problems that have emerged during development of the methodology and the subsequent analysis.

These problems or challenges are broadly associated with process and practice, governance and leadership, skills and education, organisational culture and institutional arrangements, and research-policy engagement for the next cycle of ongoing inquiry. Some of these problems and challenges are already the subject of inquiry and are represented in the transdisciplinary and other literature. However, I highlight them to emphasise their importance as powerful potential enablers in the further pursuit of transformational transdisciplinary practice and governance.

Enabling transdisciplinarity: rethinking projects

Problem versus project focus

Focusing on problems instead of projects would allow much greater possibilities for continuity and for building on existing work. In Case Study 2, the project team had worked together in various iterations over a period of 20 or more years. This is a result of their commitment to each other and to the beneficiaries of their research (and implementation), not to consistent funding sources or stable employment. Staff turnover and institutional instability was a key challenge for Case Study 3, in terms of maintaining continuity. In addition, in Case Study 3, the team members expressed regrets that they would be unable to continue to work together or to continue the work of the project in general having built such a strong and engaged co-productive team and a deep knowledge of the context and problems. However, the team members have been very active in linking with other research and implementation activities, and trying to foster ongoing activity.

A number of Case Study 2 and 3 participants viewed their project as a sub-unit of activity in a much larger field of activity. In Case Study 2, various members of the team had a long-term involvement with a range of projects and activities to create solutions and change around smallholder poultry production and food security in Africa, and clearly expressed the view that this project was just another step on the way. They actively looked for connections and synergies outside the project boundaries and focused on long-term sustainability of their activities and support for their colleagues. In

the climate adaptation project, the team was also constantly looking for connections and links, and likewise saw the project as a step along the way. While the rhetoric of programming and projects can reflect this to some extent, what is done in practice frequently does not.

Research-policy problem focus

Creating links to connect research and policy to improve problem solving is far from simple. Court et al. (2004) describe the "parallel universes" or seemingly incompatible "worlds" or "world-views" between policy decision making and implementation, and research. It is clear that policy engagement and policy making in complex international development problems cannot be focused on a single model or approach, nor is it a linear process (Jones et al., 2013; Ramalingam, 2014). Instead, it requires examination of the "messy interplay of actor interests, values/beliefs and credibility and the power relations that underpin these three broad variables" (Jones et al., 2013, loc. 3548). To do this requires engagement in policy discussions (at all levels) from the beginning of the inquiry. This thesis study highlights some of the challenges and some partial solutions to achieve effective, systemic policy-research engagement. This is an important aspect of transdisciplinary research practice, and is also a growing area in the literature.

Crossing project boundaries

Another problem or challenge is encouraging greater permeability and co-production between projects. A project focus creates artificial boundaries, which may be useful in terms of ring-fencing the range of activities within a project envelope, but is generally not helpful in terms of synergy, continuous learning and ultimate impact and change.

In particular, the boundary of what is "in" or "out" of a project needs to be less prescriptive and more flexible. There is often much discussion about what is research and what is implementation, with a false separation between the two. An example of this is the (now outdated) very top-down approach of the linear pathway from research to agricultural extension and advice. Such a one-way pipeline does not allow for co-production of knowledge to occur between researchers and so-called recipients. Despite the move away from this linear approach, there is potential for further blurring of knowledge boundaries between researchers, implementers and recipients.

The challenge here is to encompass a broader definition of research practice. This is not an invitation to drop standards of research or sacrifice rigour, rather it means seeing a broader range of subject matter as the subjects of research as well as a broader range of knowledge inputs. For example, implementation of social change, policy engagement and formulation, etc., are all important subjects for research – just as (if not more) important than climate science, agronomy, veterinary science or community health. The tendency is to regard these aspects as implementation rather than research. This means also that the boundaries between research and practice should be quite permeable and variable, and require an adaptable approach.

For example, in a recent research project I worked on, a number of NGOs were key stakeholders in the research, not because they were researchers themselves, but because the work they were doing and the knowledge they held was key to informing our research activities. Furthermore, the NGOs were keen to include a research component to study aspects of their development project implementation.

This raises the problem of power asymmetry between the value placed on knowledge from different disciplines, between donor and implementer, between researcher and practitioner, between Western and other cultural groups, and between male and female knowledge. This is greatly influenced by the disciplinary background and experience of the donor actors and the project leader. Biophysical scientists with a particular expertise were leaders in all of the case studies, which points towards the power asymmetry between different disciplines – particularly between the physical and social sciences. Gender also plays an important role with two out of three of the project leadership teams being male; the third was a female in a nearly all female team.

More importantly, there is still an assumption that Western knowledge and science is better, which risks excluding potentially powerful other ways of knowing, and learning. Furthermore, engagement with unfamiliar ways of knowing is to “accept the risk of putting to the test our beliefs and our ignorance” (Santos et al., 2008, p. xxxi).

Enabling transdisciplinarity: researcher capacities

The practice of humility

The issue of power asymmetry has a broader focus, with disciplinary knowledge tending to outweigh practical experience and knowledge, and the dominance of Western cultural ways of knowing. Santos et al. describe the "diversity of knowledge systems underlying the practice of different social groups across the globe", the dominance of Western scientific knowledge, and the historical suppression of non-scientific as well as non-Western forms of knowledge, which they (rather dramatically) call a "form of epistemicide" (2008, p. xix).

On this basis, I urge caution against complacency or assumptions about knowledge. In particular, I highlight the need for humility and an open mind towards epistemological diversity in research, particularly in relation to cultural differences. This is clearly supported by Augsburg (2014), who lists transdisciplinary characteristics including tolerance, acceptance of the unknown and ideas opposed to one's own, rigour in argument, openness to myth and legend, recognition of different levels of reality and respect for the collective. In international development, there is often a tendency to overlook what may be fundamental cultural differences (language difficulties aside) and the underlying beliefs, values and knowledge systems that make communication and mutual understanding difficult, and can lead to major mistakes and misunderstandings by researchers working in an unfamiliar cultural environment. The difficulty is Rumsfeldian. It is not the known unknowns that are the problem, it is the unknown unknowns. Dealing with these unknown unknowns requires humility, self-reflexivity and a high degree of open mindedness, not to mention a strong stomach. Clark et al. (2016) highlight humility as the ultimate requirement for researchers in complex systems contexts to generate usable knowledge.

Learning transdisciplinarity

The next question that this thesis raises, is how are transdisciplinary researchers made? What is required to train and empower researchers who can implement a methodology such as this? At the Australian National University, the Fenner School of Environment and Society offers interdisciplinary degrees and promotes transdisciplinary teaching.

There are a growing number of faculties and schools which are promoting such approaches. Wiek et al. (2011) describe an emerging academic field that is "problem-driven and solution oriented" and focused on sustainability, and that the field of sustainability science has blossomed, with new journals, conferences, academic societies and a strong focus on sustainability science and transdisciplinarity in higher education (Wiek et al., 2011). They describe a series of key competencies for academic program development in sustainability science including systems-thinking, anticipatory (future thinking), normative (mapping values, principles, goals etc.), strategic and interpersonal competencies in their review of literature.

The other requirement for training transdisciplinary researchers is the ability to understand concepts such as ontology and epistemology, and to be able to reflect at a deeper level (here called reflexivity) on what they bring to the research and how they perceive it. How widely this is being done and how effectively, and how this translates to a transdisciplinary approach to research is still to be answered. For example, my own undergraduate science degree did not include any exploration of the philosophy of science, nor exploration of alternative epistemological framings or methodologies.

Many of the researchers I interviewed demonstrated a willingness to learn and to adapt to new methodologies and approaches, despite the uncertainty and unknowns this brought into the research practice and process. The ability to be reflective and self-reflexive was key to researchers' ability to learn and adapt. As an example, one of the senior (and highly respected) researchers underwent what I would describe as a transformation. At the start of the project, he was dismissive of the role and relevance of social science, and by the latter part of the project was not only engaging productively with the social scientists, but starting to appoint them in his own department.

Transdisciplinary leadership

Good leadership is a cornerstone of transdisciplinary practice and governance, as I describe in Chapter 12. The characteristics and practice of such leadership in transdisciplinary research practice requires further thought. In her seven principles for evaluation of transdisciplinary research, Klein (2008) highlights leadership as a key theme, and concurs with Gray's (2008) characterisation of cognitive, structural and processual tasks and abilities for effective transdisciplinary leadership. Gray describes

such roles as boundary spanning, judgment, relationship and knowledge brokering, trust building, mediation, and so on (2008). The list is impressive as is the required skill set. However, Gray also highlights the need for distributed leadership within teams, and suggests that transdisciplinary collaborations could be framed as innovation networks (2008). Volckmann emphasises the importance in transdisciplinary practice of developing a clearer understanding of the way we conceptualise terms such as leader, leading and leadership (2014, p. 257).

This thesis describes three contrasting leadership approaches for each of the three projects (see Chapter 12), studied through the lens of the five principles and highlights the challenges and dilemmas these leaders face. However, leadership is not just about the project leader, and is distinct from the management role. Good leadership should also be a characteristic of transdisciplinary practice, whether or not it involves a management role. Recognising and rewarding these characteristics is essential, rather than focusing purely on disciplinary expertise and academic track record.

Complex adaptive leadership may be a useful framing to address this challenge. DeRue conceptualises leadership as a socially complex and adaptive process of leading-following – where leadership is a social process where the team members engage in a series of leading-following interactions to co-create identities, relationships and roles. Such leader-follower relationships do not counteract formal authority structures, nor are they conflated with them. Instead, complex adaptive leadership complements, and is influenced by, formal authority structures (DeRue, 2011). This approach relates back to the idea (or metaphor) of a self-organising and complex adaptive system approach to transdisciplinary research that I describe in Chapter 12. Such an approach allows for emergence and adaptation. Ramalingam (quoting Marshall Ganz) describes the "distributed leadership" of President Obama's 2008 campaign where leadership was not about the specific person, but about emergent systemic interactions between actors. Obama's campaign relied on thousands of people (including volunteers) acquiring and practising leadership skills in a distributed way (Ramalingam, 2009).

Governance for transdisciplinary practice

Reframing governance

Governance for transdisciplinary research also requires further thought. The strong focus on accountability in projects (mainly from a budgetary perspective) and on documentation for donor scrutiny is fairly standard practice in research funding, particularly in international development. In Chapter 12, I discuss the need for iterative process, governance, and reflective and reflexive learning, and the scope and need for more emphasis on this in transdisciplinary research.

This research raises the question of whether the kinds of accountability- and results-based governance framing, approaches and processes which dominate in international research for development, are helpful or restrictive for transdisciplinary research tackling wicked problems. Much of the discussion around governance arrangements in the case study projects (and other projects I have been involved in) focused around specific roles and formal rules, rather than a deeper examination of the principles and functions of such governance.

Related to this is the current predominant focus on the project unit rather than the problem. While I am not advocating doing away with projects in general, I am suggesting that projects could be more clearly reframed as a unit of activity within an ongoing problem-solving trajectory. A consistent problem focus on the other hand can be seen by donors to be repetition or double up. Case Study 3 is a good example of this – with lengthy discussions between the project team and the funding agency on scope and focus. The focus on climate change adaptation was shifted to climate variability adaptation, but the inevitable links to food security caused some concern as this was seen as a separate program area. This highlights again the challenge of negotiating between policy directions of donors and the rapidly changing realities on the ground and the generalized nature of the complex problem description. Just because two projects include the words “climate adaptation” and “food security” in their title or description does not mean they are the same or even overlapping.

A more useful framing for governance may be to look at it from a co-productive perspective as described by Wyborn (2015). Wyborn defines governance as concerning “the various processes and structures shaping individual or collective action (Young,

1992), solidified through formal or informal norms or rules (Lebel et al., 2006)" (Wyborn, 2015, p. 56). Rather than focusing only on accountability and documentation, I suggest a stronger focus on a knowledge co-productive approach to governance, where the focus is on relationships and the "social and political processes through which science, policy and practice co-evolve" (Wyborn, 2015, p. 56). This would allow for a richer dialogue and inquiry process and for new and innovative solutions to emerge. I suggest that adaptive governance and co-production should focus on relationships and dialogue, rather than focusing on a rules-based approach of processes and accountability mechanisms.

In Case Study 3, the mid-term review process focused on outputs, milestones and impacts. The researchers, however, wanted a dialogue and interaction-based approach, to consolidate learning and explore emerging ideas and approaches. An alternative way of reviewing a complex research project such as this could be to look at research process and practice as well as the potential and actual outcomes and impacts. By research practice I do not mean research methods, but the practices one undertakes in research. So in a particular research situation, I would ask myself the questions, "What will be my practice in this situation?", "How do I do the research that I do?", "Why do I do it that way?", and "How effective is my practice and how can I improve it?".

This potentially creates a nexus between the competing goals of accountability and an iterative, learning-based approach. I suggest that this could be regarded as a positive opportunity for greater innovation and learning, but would require transdisciplinary practice and literacy among donor actors, and the kind of leadership associated with this approach.

Enabling and rewarding good transdisciplinary practice

Producing good transdisciplinary researchers is not sufficient. There needs to be a system to enable and reward their research practice. On one hand donors demand outcomes and impact from research, while at the same time, researchers are rewarded based on journal publication statistics. In addition to the focus on academic publishing, researchers are generally rewarded on a disciplinary basis. Institutions are ranked and rewarded on the basis of academic publishing around lists of disciplines that may or

may not reflect what researchers actually do, and certainly reflect to a limited degree the rapid changes in disciplines and the rapid rise of new interdisciplines. Funding for "public good" research shrinks further every year in Australia to allow for the supposed expansion of research that can be patented and provide a direct and immediate cash return on investment.

Cronin (2015) suggests that interpreting "rewarding" as a verb rather than just an adjective. While transdisciplinary approaches are rewarding in terms of tackling wicked problems, rewarding transdisciplinary researchers (the verb) remains problematic. He distinguishes between the scholarship of discovery (original research to advance knowledge which is the most highly rewarded), scholarship of integration (synthesis of information across disciplines), scholarship of application (application of expertise to address community need), and scholarship of teaching and learning.

Physical and temporal constraints emerged as key constraints for researchers in the thesis study. The system of time allocation of individual researchers against particular projects can range from as little as 5% (equivalent to a couple of hours per week), to rarely more than 80%. A researcher's ability to focus and deliver substantive and quality work on complex systems issues when their time may be divided over a relatively large number of projects is problematic. It becomes more problematic as the level of complexity and wickidity of the research problem increases. Added to this are the travel requirements for international development (particularly for Australian researchers, given Australia's isolation), and the relatively short timeframes for research projects – generally between three and five years. And finally the added pressure, difficulty and time spent searching and applying for funding for follow-on projects or simply to stay employed. (Employment for researchers is increasingly unpredictable and short-term, as the instability of the organisations they work for increases.) This is counterproductive to good research practice, particularly in a transdisciplinary context, where reflection and reflexivity, iterative processes and co-production are so important.

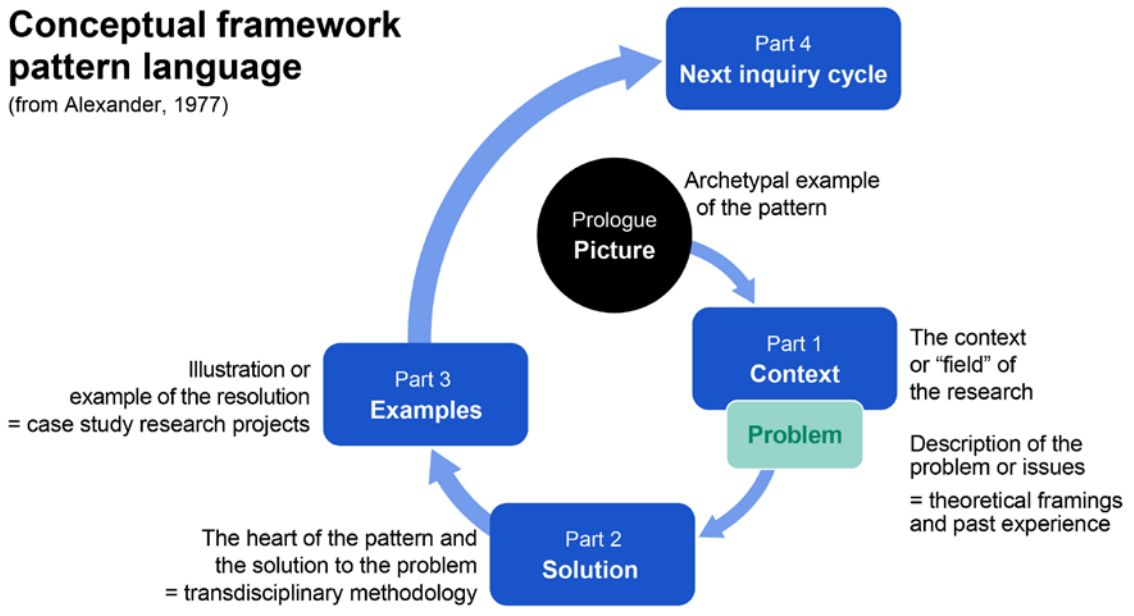
Conclusion

The five principles and their associated pattern sets for a methodology for transdisciplinary research practice come from a study of existing transdisciplinary practice. I began this thesis out of frustration at the patchiness of this practice in my

own working environment, and a curiosity and desire to study, document and understand what constitutes good transdisciplinary practice. The good news is there is a growing study of, and literature on, what makes good and effective transdisciplinary practice, and how to tackle wicked problems in complex systems.

The title of this thesis is "The synergies of difference: Strengthening transdisciplinary research practice through a unifying methodology". The five principles for transdisciplinary inquiry and practice are an attempt to seek a rich and exciting synergy by bringing together the incredible diversity of knowledge, culture and ways of being on our planet. This is only a start. These are not necessarily the only five principles, nor are the associated tools the only possible tools. The next step is to test these in the design and practice of other transdisciplinary projects tackling wicked problems.

The conceptual framework outlined in Chapter 1 serves as a sound basis for the structure and process of this thesis, and potentially as a transdisciplinary research process to implement the transdisciplinary methodology in five principles. In the thesis, the conceptual framework enabled an iterative and reflective approach to the research. It allows for continuous learning by participants throughout the process that is a central tenet of this thesis and of transdisciplinary research more generally.



I finalised the writing of this thesis during Australia's hottest summer on record (with concerns that climate change will happen faster than predicted), as millions of refugees flood out of the wreckage of Syria and its cities, and the resultant refugee crisis is dividing nations worldwide. A tuberculosis epidemic (a disease supposedly controlled by modern medicine) is ravaging parts of Papua New Guinea, our nearest neighbour. Poverty and inequality are growing globally. These and many more wicked problems cannot be successfully tackled using disciplinary or simple problem-solution approaches. This transdisciplinary methodology is an attempt to open up new thinking and approaches, rather than simply tinkering at the edges with existing methodologies and ways of thinking. This applies not just in international research for rural development, but in the broader sphere of complex systems research. Collective approaches to problem solving and the ability to bring together the many kinds of knowledge and worldviews for novel solutions and new thinking offer some hope that research can make substantial, relevant and positive contributions to addressing the challenges we are facing.

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