

Combining a cognitive framework and a co-innovation research strategy to address water use efficiency

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Abstract. We describe the application of a cognitive tool, the Cynefin Framework (CF), in assisting researchers to recognise the level of complexity of their research and in choosing the most appropriate strategy to investigate their research topic. A case study of on-farm water use efficiency (WUE) is used to highlight the application of the cognitive tool to a complex research problem, and to define a research approach best suited to this problem. WUE has been considered as a simple problem, with solutions focussed on farm-scale technology transfer. Using CF we establish that WUE is in reality a complex problem, thus needing a more sophisticated research strategy such as co-innovation. Co-innovation is a multi-directional, multi-actor process best suited to addressing complex problems for greater impact. In this case, the impact included a change in the way the WUE issue was framed and the development of a new research approach. We conclude that, where a common public-good resource such as water is concerned, and where multiple values and interests exist, the research problem should be treated as complex and thus a co-innovation research strategy be pursued.

Keywords: co-innovation, complexity, Cynefin, water use efficiency

Introduction

The theory of complexity has been a topic of discussion amongst agricultural research and extension networks for some time. Farming is facing complex challenges such as balancing production improvements and the resulting environmental footprint. Understanding the nature of complexity in addressing agricultural research problems is essential because many issues facing the sector today are harder to define and correspondingly harder to solve, in spite of a pressing need to do so (Turner et al. 2015).

In this paper we examine one such complex challenge – management of on-farm irrigation to improve water use efficiency (WUE) in a river-based irrigation scheme. For a long time, the strategy to improve WUE was simplified as a matter of matching demand with supply; i.e. matching crop and soil needs with the amount of water available. However, uptake of this irrigation practice by farmers has been limited and the achievement of WUE in this catchment continues to be a challenge (Davoren, Aqualinc Limited, 2015, pers. comm.; Srinivasan et al. 2017a; Srinivasan & Elley 2017b).

Using a cognitive tool, the Cynefin Framework (Kutz & Snowden 2003; Snowden & Boone 2007), we examine the characteristics of the WUE problem, concluding that it is complex, rather than simple in nature. Then we describe the use of a co-innovation approach to researching this issue, resulting in the evolution of the research strategy to better match the level of complexity of the WUE problem. We conclude by discussing what it means to classify WUE as complex and the implications of this classification for researchers.

The characteristics of the WUE problem

A systems analysis was conducted by the research team (Srinivasan et al. 2017a) to map out the many influences on farmer uptake of current WUE technology, creating the irrigation water management landscape diagram shown in Figure 1.

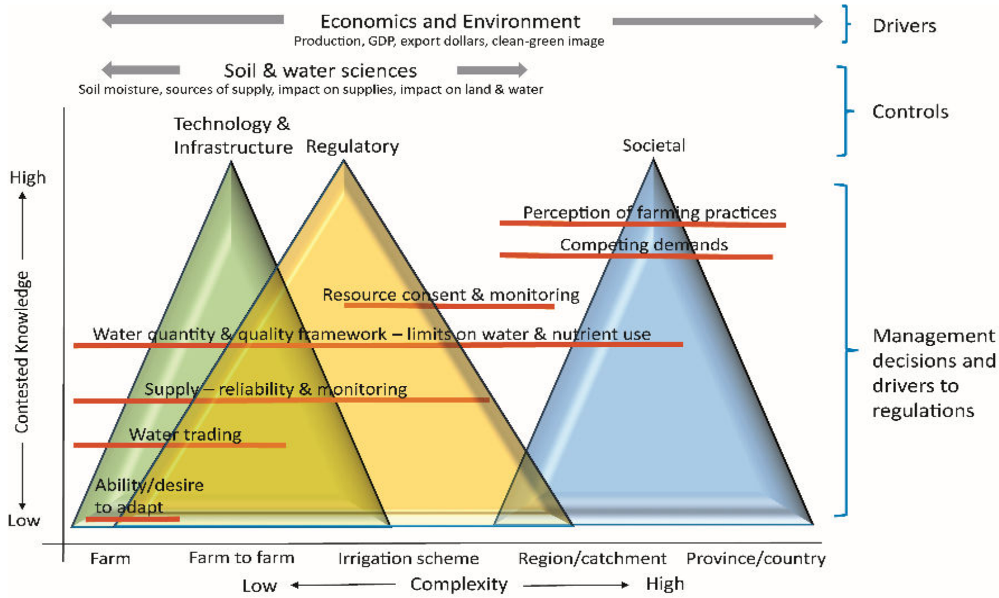
The landscape assessment illustrated that the barriers to uptake were not only farm specific. Many others were important to the wider irrigation sector and government, e.g. water quantity and quality policies of the irrigation scheme managers and regional council.

Examples of these barriers to uptake and wider influences on the WUE landscape are given below, moving from farm scale, to the scheme, regulatory and national scales:

Farm scale barriers

- While demand for water can be measured, farmers are expected to analyse the demand, assess the uncertainty associated with the forecast weather, take stock of current supplies (river flows and on-farm storage) and schedule an irrigation. The ability of soils to hold this irrigation, once applied, also needs to be understood. Generally, such knowledge and the time to do this analysis are challenging to farmers.

Figure 1. Irrigation water management landscape of New Zealand



Source: Adapted from Srinivasan et al. 2017a.

- Regulatory conditions mandate a high irrigation efficiency (e.g. 80% of irrigated water should be available within crop rootzone (Environment Canterbury 2017), though no precise tools are available to monitor this in real time. Thus, there is a mismatch between expected behaviour and farmers' ability to achieve the behaviour.
- Even for those farmers who have the willingness and desire to change, there are infrastructural barriers to the uptake of a highly efficient approach; for example, the ability of irrigation equipment to alter irrigation applications to match the demand and supply.

Irrigation scheme and regulatory scale barriers

- At the scheme and regulatory level, WUE is now seen as the first and critical step towards nutrient management. The introduction of Good Management Practices (GMP) for nutrient management by the regulatory authority, Canterbury Regional Council (Environment Canterbury 2017), acknowledges the need for irrigation management and reflects the technically complicated nature of the irrigation issue. However, the introduction of these nutrient requirements has further increased the complexity of irrigation management at the scheme and catchment level.
- Alongside human factors such as those listed above are scientific challenges. Irrigation is scientifically complex as contaminants move through the environment differently. Sediment, phosphorus and microbes move in over-land flow (over-irrigation in a poorly draining soil can result in overland flow), and nitrogen, microbes and phosphorus can move in subsurface flows. Therefore, WUE has to be optimised at the farm, scheme and catchment levels in a way that influences these multiple pathways.

National scale barriers

- Overlaid across these infrastructural and scientific complexities is the society-level debate about the competing demand for water allocated for irrigation compared to municipal, recreational, cultural and environmental purposes.
- These competing demands for water has led to public scrutiny of farm practices in general and irrigation practices in particular. Stakeholders participating in this systems analysis identified insufficient articulation amongst irrigation stakeholders of the environmental, economic, cultural and social benefits of managing irrigation better as another barrier to the achievement of WUE.

Applying the Cynefin Framework and a co-innovation research strategy

The following sections of this paper use the WUE example to illustrate the value of a co-innovation research strategy to address the complexity of water use efficiency (see AgResearch 2017 for more information on co-innovation). The focus is on the impact of the research strategy on the framing of the research topic. For a discussion of the broader outcomes of this research strategy see for example, Srinivasan et al. (2017a) and Srinivasan & Elley (2017b).

About the case study

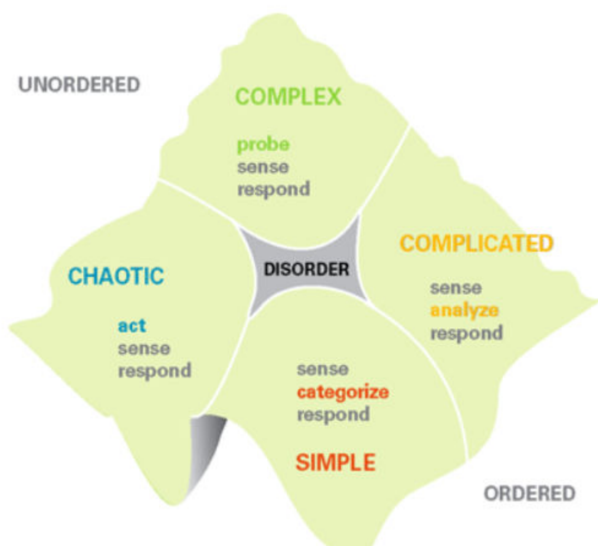
The Waimakakariri Irrigation Scheme WUE case study was launched in 2012 as a part of the New Zealand (NZ) government-funded Primary Innovation program. One aim of the program was to research, record and address the challenges to uptake of efficient irrigation practices among farmers in the Waimakariri Irrigation Scheme. Using a type of research strategy called co-innovation, researchers worked with five pilot farms. Each farm was instrumented to monitor soil water demand using soil moisture sensors. Additionally, each farm was supplied with two to six-day, area-specific, rainfall forecasts. This enabled informed irrigation decisions that were based on current soil water demand and short-term water supply. Over the five-year program, researchers and farmers worked closely on refining the biophysical data collection and dissemination, and shared experiences, which are described in detail in Srinivasan et al. (2017a).

During the course of the program, other stakeholders, such as regulators, industry professionals (dairy, irrigation) and irrigation scheme managers, worked to better formulate and describe the complexity of the water use issue in Waimakariri. The focus of these interactions was on the connectivity between the issues using co-innovation techniques, such as systems mapping. The next sections describe the CF with a focus on understanding research strategies best suited to complex problems.

The Cynefin Framework

The Cynefin Framework (CF) is a cognitive tool to understand research problems such as WUE in order to match the problem to the most appropriate research strategy. According to the models' characteristics, there are four main system types into which research problems can be placed: simple, complicated, complex and chaotic. Figure 2 illustrates these system types, together with the most appropriate research strategy for each type.

Figure 2. The Cynefin Framework showing the value of probe-sense-respond approach to a complex problem like WUE



Source: Snowden 2017.

According to CF, a simple system refers to a system where cause-effect relationships are clear and well understood and a sense-categorise-respond process is best used. For example, developing a farm-specific nutrient application plan through soil sampling and testing belongs to this system. In this case it is a matter of measuring moisture levels in the soil (sense) against pre-defined categories of desirable levels (categorise) and adjusting the irrigation accordingly (respond). Simple problems are those where the problem definition and responses applied should be 'best practice' (e.g. nutrient scheduling through soil testing), and typically, a technology-transfer approach (such as a soil test) will adequately address the issue.

In contrast, complex research problems are those where cause-effect relationships are non-linear, dynamic and correspondingly difficult to define and investigate. The relationships between the controlling variables vary in space and time, if they exist at all, and the best research strategy is probe-sense-respond. That is, test and implement ideas early in the research process (probe). Next, analyse the results using social processes such as workshops to enable a diverse range of people to interpret the findings (sense). Finally, move into the early implementation of interim ideas and recommendations (respond) in a repeating process of what Snowden (2017) refers to as 'trial and learn' experiments or 'emergent practice'. The aim of a probe-sense-respond research strategy such, as co-innovation, is to synthesise different types of data and knowledge, reducing bias and increasing options for how to tackle the research problem. The next section applies CF to water use efficiency and shows how the research team used co-innovation methods resulting in a shift in problem definition from simple to complex.

Application of the Cynefin Framework to the WUE casestudy: a shift in problem definition from simple to complex

Initially, the need to increase WUE on farms in the irrigation scheme was classified by researchers and water resource managers as a simple problem. Farmers had been irrigating using a 'just-in-case' approach, where irrigations were based on water supply rather than demand. Since the irrigation source, the Waimakariri River, frequently drops below irrigation abstraction level during summer, farmers were applying water when it was available - 'just-in-case' it ran out. This resulted in over-irrigation, leading to leaching and poor use of soil-available nutrients, with a direct impact on production and the environment.

In contrast, deficit irrigation, or a 'just-in-time' approach, which has been proposed over several decades, is based on water demand rather than water supply management. This approach needs the farmer to have a knowledge of current demand, which usually is achieved by measuring soil water content with soil moisture sensors. The problem and solution appear simple – farmers need to move from a 'just-in-case' irrigation approach to a 'just-in-time' approach; measuring soil moisture and scheduling irrigations accordingly. The cause (poor irrigation) appears well related to the effect (poor production, environmental impact). However, this shift from 'just-in-case' to 'just-in-time' has not been adopted by farmers (Srinivasan & Duncan 2011; Srinivasan et al. 2017a).

Given the poor uptake of a solution to address what appeared to be a simple problem, the research problem was reclassified as complex, and the research strategy changed to one more appropriate to address this complexity. Through the lens of CF, the approach shifted from seeking best practice solutions to seeking emergent solutions by bringing diverse groups together to harness their different knowledge bases, perspectives, and preferences for action.

Following this reclassification of the problem as complex, social processes such as workshops and discussion groups were woven into the project, including 'trial and learn' experiments and pro-active engagement with farmers, researchers, regulatory agencies and industry bodies. These stakeholders explored the drivers, controls, and limitations to uptake by farms of 'just-in-time' and 'just-in-case' irrigation approaches. Co-innovation tools were used such as system mapping, iterative feedback, interactive workshop, process coaching ('Reflexive Monitors') and evaluation.

The pilot farms' irrigation practices were tracked and reported back into these multi-stakeholder and mixed method processes. This assisted the research team to make sense of the data and develop new actions (Blackett in progress). For example, farmers whose monitoring data showed changes in practice, were urged to continue. Whereas farmers with no change, were engaged in a new cycle of engagement and research. For example, previous irrigation evaluation studies in the Waimakariri irrigation scheme (e.g. Srinivasan & Duncan 2011) were reviewed, indicating that the poor irrigation practices were largely linked to unreliable river flow, that is, water supply. Owing to poor supply reliability, farmers paid less attention to current soil water demand or weather forecasts than they perhaps could in order to use water more efficiently.

Through these discussion and research processes, it was identified that the science of weather forecasting had advanced and project participants developed an approach that combined current demand and future supply, to mitigate the unreliability in river water flows. This resulted in the inclusion of weather forecasting into the project and another reframing of the research topic occurred. The focus shifted towards farmers adopting a 'justified approach' to their irrigation management. Tailored local weather forecasts were created by the researchers and emailed directly to the farms every day. Farmers who had not previously achieved irrigation management targets began experimenting with scheduling their irrigation according to when they needed water, as well as when rain was forecast, reducing their perceptions of the risk of under-irrigating and crop failure.

Concluding comments

Understanding the nature of complexity in agriculture is essential because many issues facing the sector today are harder to define and correspondingly harder to solve, in spite of a pressing need to do so. We examined a cognitive tool, CF, as a means to assess the level of complexity of WUE using a case study. Working with stakeholders in interactive and experimental social processes, led to the reclassification of a simple problem to a complex one and changed the way that the research was approached and solutions implemented.

The WUE case study started at a farm scale as a simple model, in terms of CF, falling into chaos because of poor application of our understanding of irrigation management, as indicated by the poor uptake of irrigation technology. When looked at through the lens of CF, irrigation management evolved from simple to complex. The cause (poor irrigation) and effect (environmental, economic) may be known in broad terms, but at the farm level, where practice and behaviour changes are required, the relationship between cause and effect is mediated by influences within and outside the farm.

In summary, a system analysis of WUE highlighted that irrigation management is not merely a data management issue (measure-monitor-manage) but includes both biophysical and social dimensions. Water is a public resource, and hence values, expectations, and uses abound. Solving the challenges inherent in irrigation management requires accessing the ideas, resources, and motivation of others in the wider irrigation system, using a range of social processes. Because complex problems are characterised by many different influences on them, typical biophysical strategies such as measure, monitor and manage will not work well in isolation.

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