‘Ways of knowing’ water quality

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Abstract
This paper explores dairy farmers and science-policy ‘ways of knowing’ water quality. Based on case-study research undertaken in the Manawatu-Wanganui region, different ways of knowing water quality were evident. Some farmers believed more emphasis was placed upon science-policy ways of knowing above farmers’ ways of knowing. This belief contributed to farmers’ disregarding and disbelieving Horizons’ information and contributed to the strong farmer resistance to Horizons One Plan. This paper poses the question: how can multiple ways of knowing water quality be acknowledged so stakeholders can communicate and participate more effectively in policy making processes?

Key words:
Ways of knowing, water quality, collaborative policy processes, dairy farmer, local knowledge.

Introduction
The state of New Zealand’s freshwater quality has declined, and intensive dairying is one identified contributor to this decline (Parkyn, Matheson, Cooke, & Quinn, 2002; Parliamentary Commissioner for the Environment, 2013; Smith, Wilcock, Vant, Smith, & Cooper, 1993). A suite of water quality interventions was progressively introduced by the dairy industry, and by central and local government to address this decline in freshwater quality. Two successive voluntary accords were introduced by industry (DairyNZ & DCANZ, 2013). In addition, New Zealand’s largest dairy company, Fonterra, introduced Supply Fonterra: an education programme to deliver good practice guidance and support to dairy farmers (Fonterra, 2013). Central government introduced the National Policy Statement Freshwater Management (NPSFM) (Ministry for the Environment, 2014) to guide regional and district council decision making. Regional and district councils use a mix of interventions, such as regional plans, education and economic incentives to implement the objectives of the NPSFM, and to manage freshwater quality in their regions.

Horizons Regional Council manages water quality in the Manawatu-Wanganui Region of New Zealand. A decline in regional freshwater quality over time, necessitated increasing water quality monitoring and intervention by the regional council. Horizons use their regional surface water quality monitoring data to inform decision making about policy development and non-regulatory initiatives (e.g. subsidies, education). In response to declining regional water quality, Horizons adopted a regulatory approach to water quality management, and prepared the One Plan (Horizons Regional Council, 2014). Horizons notified the Proposed One Plan

(POP) in May 2007, informing the public of the proposal, and allowing submissions on the proposed plan. After the POP submission and independent hearings process, over 20 parties (including Federated Farmers, Fish & Game and Horticulture New Zealand) filed appeals on the POP to the Environment Court in 2010 ("Horticulture New Zealand V Manawatu-Wanganui Regional Council," 2013). After the Environment Court and High Court processes, the One Plan became operative in 2014 (Horizons Regional Council, 2014).

The One Plan takes a targeted approach to water quality management and specifies the Water Management Zones where the management of intensive farming land use activities must be specifically controlled. Under the One Plan, intensive land users in targeted Water Management Zones (WMZ) must obtain a Land Use Consent, and introduce mitigation strategies to reduce their nitrogen leaching (kgN/ha/yr), over a specified time frame, to the plan's agreed targets (Horizons Regional Council, 2014). Farmers in non-targeted WMZ do not require a Land Use Consent. The nitrogen flow and nitrogen leaching from each farm system (kgN/ha/yr) is calculated and estimated by the predictive modelling tool Overseer®. With a goal of maximising and protecting the value of water quality, the objective of this paper is to explore Manawatu-Wanganui dairy farmers and science-policy 'ways of knowing' water quality to help improve future engagement in collaborative policy processes. The following sections provide insights from the 'ways of knowing' literature used in this paper.

'Ways of knowing'

Ways of knowing can be thought of as 'dynamic social sense-making systems, including both ideas and practices, that signify distinct meanings' (Ingram & Lejano, 2009, p.62). Ways of knowing are created through social interactions and relationships between people (Ingram & Lejano, 2009), and as such, ways of knowing a topic or issue emerge through changes in the relationships between individuals and other elements within their system (Feldman, Khademian, Ingram, & Schneider, 2006). Being a 'dynamic and mobile rather than fixed and static' concept (Ingram & Lejano, 2009, p.62), ways of knowing are argued to be constantly evolving from new interactions, from ideas and information being shared and from experiences being experienced. Ways of knowing farming, for example, may emerge through changes in the relationships between farmers, the individuals or groups they interact with (e.g. advisors, policy staff, general public), the information they obtain through their networks and from practical experiences. Feldman et al. (2006) suggest that interest is a reason why an individual gravitates towards a particular way of knowing, therefore following this argument, an environmental or sustainability interest may lead a farmer towards an organic way of knowing farming.

Central to ways of knowing is the premise that knowledge is not static, but dynamic and is continually created from experiences and from social interactions with others (Brugnach & Ingram, 2012b). Furthermore, different types of knowledge exist, for example, factual systematic knowledge created from quantifiable empirical data and experiential and traditional knowledge created from practice and experience (Brugnach, Dewulf, Pahl-Wostl, & Taillieu, 2008; Brugnach & Ingram, 2012a). Different types of knowledge contribute to different ways of knowing.

Ways of knowing water

Ways of knowing is a concept that helps us understand how people approach the management of natural resources such as water. As Ingram and Lejano (2009, p.61) explain, 'water is a complex multifaceted resource reflecting very different values and ways of knowing'. Multiple stakeholders are involved in water management, which implies a multiplicity of ways of knowing water and finding solutions (Brugnach & Ingram, 2012a). Importantly, although multiple and different ways of knowing may exist, all may be legitimate and reasonable (Brugnach et al., 2008). For complex systems such as water, recognising and involving a diversity of ways of knowing, and in particular non-scientific knowledge holders, is a way of increasing understanding and engagement in water management (Freitag, 2014). Furthermore, what is known about water relies not only on scientific or expert knowledge, but on stakeholders knowing through tradition, practice and experience and from their interactions with others (Brugnach & Ingram, 2012b).

Ways of knowing water and inclusive policy processes

Feldman et al. (2006) argue that policy issues and people's reactions to issues are socially constructed through social interactions and relationships. They propose that ways of knowing will assist in understanding how stakeholders structure and know about a policy issue, thereby resulting in policy managers being more able to create opportunities for engagement and discussion. Collaborative and inclusive water management processes attempt to involve multiple stakeholders and to acknowledge that stakeholders have multiple and equally valid ways of knowing, of understanding a problem, and of finding solutions (Brugnach & Ingram, 2012a, 2012b). Inclusive processes bring people together from different perspectives with different ways of knowing, to allow them to appreciate different issues from different perspectives. A collaborative process may acknowledge that different groups and individuals perceive problems differently, based on a range of factors, including their: backgrounds, past experiences, social context, opinions, values, beliefs and the individuals and groups they interact with (Brugnach & Ingram, 2012a). Processes that rely on scientific and expert knowledge can overshadow the experiential knowledge from local or indigenous sources, thereby limiting the potential for diverse perspectives and collective action to occur (Brugnach & Ingram, 2012b).

Duncan (2016) explored New Zealand farmers' responses to the process used to set nutrient limits to achieve agreed water quality goals and to the regulatory intervention (a regional plan) that set the limits. Her research investigated how farmers and policy makers framed and conceived water quality, or their ways of knowing. Her study found a divergence between farmers and policy makers ways of knowing the water quality problem: what farmers observed and knew about their land differed from what science modelling was indicating. Duncan's (2016) findings suggest that problems and solutions need to embrace multiple ways of knowing; an approach that considers the differing values and beliefs of groups and individuals.

Diverse ways of knowing water quality were also reported by Freitag (2014). From research in North Carolina, experiential knowledge (from a fishing community), academic knowledge (from the scientific community), and political knowledge (from policy makers) were identified. Although diverse ways of knowing were recognised by participants as relevant for water quality research and management, a disconnect between policy implementation and the 'on-the-ground knowledge' (p. 336) was evident. The need for trust and improved communication between stakeholder groups was critical to reduce this disconnect. Freitag (2014, p.336) concluded: 'a multifaceted problem needs multifaceted solutions'. The next section explains the research methods.

Research method

This paper reports some findings from a comprehensive PhD study of Dairy Farmers' Responses to Water Quality Interventions (Collins, 2018). The qualitative research presented in this paper, was conducted in 2015 using a case study research strategy (Stake, 1995), and expanded to include current developments in Horizons' Catchment Planning Process (2018). A single-case study design was chosen for this research to enable an exploration of the 'how', 'what' and 'why' of dairy farmers' responses to water quality interventions. The Manawatu-Wanganui Region of New Zealand, managed by Horizons Regional Council, was the site for this single-case study. The Upper Gorge Water Management Zone was selected as the study site, because this WMZ contains both targeted and non-targeted subzones (as per the One Plan classification).

Document collection and in-depth semi-structured interviews with dairy farmers and key informants were the main data collection methods (O'Leary, 2014). The documents included legislation and submissions, planning documents, statistics, media articles, technical reports, educational materials, and industry surveys. Twelve dairy farmers from the Upper Gorge Water Management Zone were selected using a stratified random sampling strategy (O'Leary, 2014). Questions were asked about the participant's background, current farm system, farm system changes made in the past five years, water quality interventions, relationships with others, and their views on what constitutes a 'good dairy farmer'. The concept of saturation (O'Leary, 2014) determined the dairy farmer sample size. A fictitious name was used for each farmer.

Key informants in this research were participants who were able to provide relevant information, knowledge, and a deeper insight into the events of the world around them (O'Leary, 2014). Nine key informants were interviewed after the dairy farmers, with a purposive snowball sampling method (Robson, 2011) used to identify and select the key informants specific to this case. These key informants were from a range of roles (working with farmers, to developing policy, to executive level) and a range of organisations at regional and national level. Questions were asked about the participant's background, personal involvement with water quality interventions, contact with dairy farmers, and their relationships with staff from other organisations. A fictitious name was used to ensure confidentiality. O'Leary's (2014) concept of saturation determined the key informant sample size. Both dairy farmer and key informant interviews were audio-recorded (with participant's permission) and tapes later transcribed. A thematic analysis strategy (Guest, MacQueen, & Namey, 2012) was used for data analysis.

Results

Dairy farmers 'ways of knowing' - practical experience and observation

Practical experience and observation were one of the main ways the dairy farmers in this research 'knew' water quality. The farmers talked about the farm practices they know can impact on water quality and the changes they made to their farm systems. Fred put a bridge over the creek and explained: *'I never liked walking the cows across the creek …… you know when you're walking across, they may shit in the creek'.* Jim, his wife and sons have farmed their farm for over 30 years. Jim knows '*if stock have access to them [drains], the water quality is degraded'*. He also knows how water flows over the farm after a rain event. Jim's practical experience and observations influenced his decision to fence the stormwater drains.

All our stormwater drains, our creeks, whatever you want to call them, all our waterways flow from here, and they flow to the river… If we get a rain event of 100mls overnight, on these hills, they can't take that sort of rain, so they flow to the gullies and flow to the waterways, and hence head to the river.

Jack purchased a slurry tanker to spread effluent, rather than using a contractor to annually pump out his effluent ponds. Jack had previous experience with irrigator issues ('*you'd go to work in the morning, and the irrigator had got to the end of the line and was still spinning, so there was a big black UFO circle*'), went to a local field day, learnt about slurry tankers, did some research, and further explains:

'We used to get a contractor in to pump the ponds out, but we were limited to where we could spread it, by the length of his pipes basically. So the paddocks did end up black once a year, but only the close ones to the pond. That's when you did have nutrient hotspots, and real potential environmental issues as far as leaching, because you're just piling on a whole year's worth of effluent on 8 hectares or something, rather than spreading it nice and even.'

Max and Fred know that applying effluent in the rain or on wet soils can lead to ponding and runoff. Previous experience helps them decide when to apply effluent. Max described the '*mental water balance in my head'* and he decides when to apply effluent '*depending on the weather condition and all those sorts of things.*' Fred looks at his soils and that helps him decide:

'*Generally we don't start applying it until after October and when the soil, virtually when the soils can take it [effluent]. Generally by, like I say, sight walking across them. I don't have any fancy metres or anything. We can pretty much hold it until things are well and truly dry, so if it pours down with rain, then we don't irrigate for a couple of days, until after it's dried out.'*

Dairy farmers' 'ways of knowing' - their recollections of the past

The farmers also 'know' water quality from the farm management changes they have seen since they started farming and from older farmers' or family members' memories. The farmers know that effluent in waterways reduces water quality. Paul, Jim and Ken shared their recollections of the effluent management practices when they started farming, and how these practices have changed over time. They believe that water quality must be better now because farmers have changed practice and effluent no longer goes in waterways:

'*They were saying water quality is damaged by farmers, whereas certainly in the last 15, 20 years, farmers have gone away from water-based effluent, discharge to drains and that sort of thing, to irrigation. Certainly I know it's not going in the drains like it used to when I started farming. It's improving I think, not getting worse, as far as farmers are concerned.'* (Paul)

'*But when you're as long in the tooth as I am, you think back to the 1960s, all the effluent went in the river, full stop, it all got discharged to water, it was never treated, and it went to the river. Not a drop of it goes in the river now, so surely it's better than it was. All the whey that used to be - the cream went to the factories, all the whey used to be fed to pigs. Pigsties were all next to creeks, that doesn't happen now.'* (Jim)

Ken, a third-generation farmer on the same farm, shares the changes he has seen over his lifetime:

'*Of course 50 years ago every cockie's waste went straight into the creeks, all the cowsheds were built on the little streams, and went straight in. Now that's all stopped, there's none of that now at all. When I'm talking about that population, you've only got to look at the Mangahao River down here, comes though intensive farming area, but it's always crystal clear and there's no slime in that river, ever*.'

Ian's farm has been in the family since the 1880s. He recalled how his grandfather milked 25 cows, how the effluent went into the creek, and added '*there's never been bigger eels from there down'*. Ian milks 350 cows and knows that effluent in the creek from his cows '*would flow green'*. He explains: '*That would not only ruin the water quality for stock downstream, but it would just smell, and I think farmers know you don't go blatant like that*.'

Fred also talked about water quality in the Manawatu River: '*I've been swimming in it [Manawatu River] most of my life and never got sick'*. Fred and family use a farm consultant and Fred's opinion that water quality has improved was reinforced by his trusted consultant's ideas:

'I think, all I know, it is like my consultant's told me, *the rivers, the Manawatu River is physically cleaner than it was back in the 70s, because of the improvements*.'

Science-policy ways of knowing – monitoring, research and modelling

Horizons know water quality from their regional surface water quality monitoring data. Horizons initiated a regional surface water quality monitoring programme in 1989 (Roygard, Hurndell, Clark, & Nicholson, 2011), and the establishment of a regional network of monitoring sites by 2007 increased both the frequency of measurement and parameters to be measured (Snelder, Brooker, Unwin, Wood, & Wilcock, 2014). This network of monitoring sites measures physiochemical (e.g. nitrogen and phosphate) and microbiological variables (e.g. *E.coli*) and biological indicators (e.g. periphyton). This programme identified increased nutrients, sediment and the presence of pathogens as the three identified regional water quality issues. In addition, McArthur and Clark (2007) identified the increased growth of nuisance (excess) periphyton, from the increased concentration of nutrients, as a significant regional environmental issue. Three State of the Environment (SOE) reports for the Manawatu-Wanganui Region have been released (1999, 2005, 2013), and these reports indicate declining water quality. The second SOE report claimed intensive agriculture, and in particular increased dairying, was a contributor to the declining regional ground and surface water quality (Aussiel et al., 2005).

Horizons also know water quality from external scientific research (e.g. Ballentine & Davies-Colley, 2009; Snelder et al., 2014; Young, 2010; Young & Clapcott, 2010). Snelder et al. (2014) conducted state and trend research on river water quality in the Manawatu River Catchment. State research measures river water quality against the One Plan targets and trend research measures changes in river water quality over time. State research classified the water quality in this catchment as poor (i.e. high nutrients and faecal pollution, low visibility). Snelder et al. (2014) concluded that the current poor state of water quality in the Manawatu River Catchment can be attributed to non-point source contributions from agriculture. Trend assessments of water quality (20 year and 5 year) indicated a general overall trend for improving water quality (where results were significant). In summary, water quality in the Manawatu Catchment is poor (water quality does not yet meet the One Plan targets) but improving over time.

Horizons use the predictive modelling tool Overseer® (thereafter termed Overseer) to calculate and estimate the nitrogen loss from intensive farming systems (kgN/ha/yr), and in the preparation of Land Use Consents. Under the One Plan, farmers in targeted WMZ are required to obtain a Land Use Consent and to introduce mitigation strategies to reduce their farm nutrient losses to waterways (Horizons Regional Council, 2014). Horizons uses Overseer data to determine the length of a Land Use Consent that can be issued, and the extent to which these farmers are required to change their farm management practices to reduce their farm's annual nitrogen loss to water.

Farmers' encounters with science and modelling

Although the farmers were using Overseer generated data for nutrient budgeting, their awareness of and knowledge about Overseer varied. Some, like Max, understood how Overseer worked and how to use it to assess different mitigation strategies: '*I know the things that influence Overseer, and I know how to change my management to make a difference*'.

Other farmers, like Tom, have a little knowledge ('*it's a computer model which spits out figures*') and some, like Roy, have limited knowledge *('I don't know a lot, I don't use it'*) and rely on their consultant's knowledge and advice.

The idea that a theoretical model could decide what is good and bad farming practice, was both confusing and concerning for farmers. Max thinks most farmers are negative about Overseer because it's inaccurate and theoretical ('*farmers hate not being able to see a number …. I can't see, in the water flowing off my farm, a cup full of 26 N per unit per hectare'*) and used to control their farm practices: *'it's a stick that's been put in and that it's not accurate, ……but it's used to create a number that has to be stuck to'.* Farmers are practical people, and as Max summarised: '*I can't see my N leaching out the bottom*.' Overseer upgraded from version 5 to 6 during the Proposed One Plan process, and from Max's perspective: '*they changed versions, and then it totally changes everything, and what you thought you were doing right is now wrong, that really hacks you off too*.' Jim was concerned about the credibility of Overseer, and used the word '*mockery*' to describe Overseer and the Plan that relies on Overseer:

'If I can feed data into a system that gives a figure that makes everyone happy, isn't it ridiculous? ... Again, if Overseer is a mockery, anything that relies on it becomes, by association, becomes less than creditable.'

To further compound the confusion, some farmers were surprised when their farm's annual N loss (kgN/ha/yr) prepared by their fertiliser company, differed from that prepared by other sources (e.g. Horizons, Fonterra's Nitrogen Report). Pete (Fonterra) explained why he thinks these Overseer-generated N loss figures can differ. He understands that Fonterra and the fertiliser companies rely on farmers supplying information ('*some farmers throw in the run-off for our lot and don't throw in the run-off for another lot*'), whereas Horizons' data collection is more accurate and detailed:' *they sit down with the farmer and sight everything and run through it for up to 4 hours at a visit'*. Pete shares his experiences with farmers: '*You can sit with a farmer and he'll show you his [Fonterra] nitrogen report and it says leaching 32 and he'll have his DairyNZ baseline saying leaching 42 or whatever*'. Conflicting information from seemingly the same farm data.

Fred obtained a Land Use Consent for their farm. He was frustrated with the consent process, because Overseer's representation of his farm differed from what he knows from experience and observation:

I'm not sure how the program works it out, but it said our feed needs that those cows need to produce this…. They tried to tell me that we will still do 400 [kgMS] a cow, which I know we won't do 400 a cow, because we were only doing 330 a cow, feeding twice as much brewers grain and the maize anyway. So that was one issue. The second issue was the program was telling them, and me, that we were growing 14 tonne of grass on the hills. Now I can guarantee we're not growing 14 tonne, and they wouldn't change it, they would not change it.

Fred also shared a story that he heard about another farmer from his farm consultant. His farm consultant told him: '*they measured the nitrogen coming into the property, and the water coming into the property, and the nitrogen level in the water leaving the property, and the level was lower. Yet they were still expecting him to drop [reduce N]'.*

Different ways of knowing water quality – contributions to conflict and resistance

The farmers felt that Horizons were disregarding the farmers' local knowledge, and/or putting more weight or emphasis on their own science knowledge. Max called it '*their science'* and believes *'it wasn't the whole picture*'. Some farmers, like Ken and Fred, think Horizons don't tell the whole story about the causes of water quality decline. They feel angry and unfairly blamed. Ken loves fishing – '*I spend a lot of time on rivers* - yet what he's seen over his many years is different from what he believes Horizons is telling the public about the causes of declining water quality:

'*I've come across up on the, below the junction of the Tirimia where the swans and that have been camped there, the creek, I've seen the shit six inches deep along the side of it there [from the swans]. That's all getting washed into the rivers, and yet they're still blaming the cockies you see*.'

Fred also thinks Horizons don't tell the whole story to the public:

Well there is science there, they [Horizons] know the levels coming out of the bush, but do they tell the general public? But the general public look at the water quality and go it's just dairy farmers. Whereas there's probably, I'm not sure what the figures were there, but it was one big flood after one big flood, there was a bloody lot of nitrogen come out of the bush line.

Other farmers believed that when Horizons designed the One Plan, they were only thinking about the environment and science and not thinking about the socio-economic impacts of the plan on the community. Some farmers felt angry and others felt frustrated. This led to resistance to the One Plan because the community believed they were not being listened to. Doug is a local dairy farmer and member of the TCEIS (Tararua Community Economic Impact Society). Even though he believed the TCEIS and Horizons wanted the same outcome ('*Always we asked the question, how can we improve the rivers*?'), he thought Horizons were putting more emphasis on their water quality numbers and less emphasis on the negative economic impact of the One Plan on the community. He also thought Horizons were not considering the farmers' local knowledge, were not being collaborative, and explained:

We never ever said no to the improvement of the river systems and the lowering of nitrogen, what we said no to was the way that Horizons wanted to instigate their process of improvement. That was really to reduce milk solids produced in the area and reduce the number of cows and therefore reduce the nitrogen and they say we've got it all sorted and you guys will still make as much money, which wasn't right. So we said no we don't like that process, and we think there are smarter ways of doing it, you haven't come to us with a problem *that we would like to help solve. You've just said we're going to solve it and this is what you guys will do.'*

What will the future bring?

Early 2018, Horizons initiated the design of a collaborative community catchment planning process. After legal processes around the Proposed One Plan were described by a key informant as '*disempowering for communities and the council'*, Horizons proactively ran a series of facilitated workshops to involve staff and stakeholders in the catchment plan process design. Staff and stakeholders created a set of guiding principles that will underpin their Strategy for Freshwater and the catchment planning process. Acknowledging that knowledge empowers good decisions, and recognising the importance of different types of knowledge (e.g. mātauranga Maori, western science, practical know-how), is key to underpining Horizons collaborative community process (T. Bowen, pers. comms, 10/7/2018).

Discussion

This paper set out to explore dairy farmers and science-policy 'ways of knowing' water quality to help improve communication and engagement in policy making processes. This research identified that farmers and science-policy use different knowledge systems, and as such, have different ways of knowing. Farmers know water quality from practical experience, intuition and direct observations of soil, water and landscape. In addition, farmers' ways of knowing were created through their interactions and relationships with others, and commonly with those they trust (e.g. farm consultant, other farmers, family). For some farmers, their way of knowing was based on inter-generational knowledge handed down through families, and these farmers have their own and family members' recollections of the past; a finding also highlighted by Duncan (2016). Ingram and Lejano (2009) argue that ways of knowing include practices and ideas with distinct meanings, and these were evident in this research. The farmers described the farm management practices that can improve water quality and their ideas around the causes of water quality decline. Importantly, the social process of knowledge construction identified in this research, and emphasised as central to ways of knowing by Brugnach and Ingram (2012b), ensured that farmers' ways of knowing water quality were dynamic and evolving. The farmers constructed knowledge from their own on-farm experiences, and from their interactions with others through their social networks. This social process influenced both the practices farmers chose to use to improve water quality and their ideas around the possible causes of water quality decline.

In contrast to farmers, science-policy ways of knowing water quality were based on objectively monitored data, research (by Horizons and external providers) and the predictive modelling tool, Overseer. This objective data and Overseer quantify and standardise water quality, thereby removing the dynamic variability described by the farmers in terms of differences in farm systems, climate, soils and landscape. Monitoring data and reports commonly present water quality as resulting from an increase in intensive dairying, and suggest farmers are not using best management practice; another finding also highlighted by Duncan (2016). A divergence in the ways that farmers and science-policy know water quality was clearly evident.

Some farmers in this case responded to Overseer's theoretical interpretation of the nutrient output from their farms, which differed from their own practical way of knowing and visualising outputs from their farm. In addition, Overseer's interpretation is based on a modelling tool that farmers believe from their own and other farmers' experiences to be inconsistent and inaccurate, and a tool based on science that is regularly upgraded (different versions produce different outputs from the same farm inputs). Using the trust framework developed by Kasperson, Golding, and Tuler (1992), the farmers' perceptions of Overseer's inconsistency (lack of predictability) and inaccuracy (lack of commitment) contributed to a lack of trust in this modelling tool. In some cases, a lack of trust in the modelling tool also contributed to a lack of trust in the individuals (e.g. policy staff) and organisation (e.g. Horizons) using this tool for regulatory purposes.

Importantly, this research found farmers were not rejecting the science or denying a water quality problem. The farmers in this case were questioning, sceptical and disbelieving of science data that differed from their own observations, experiences and farm knowledge; a point also noted by Duncan (2016). These findings reiterate the issues identified by Fisher (2013) in her discussion of the government's disregard of farmers' local knowledge in favour of scientific evidence in relation to bovine tuberculosis, and as she further explained, farmers were sceptical of the reliability of government information. Conflict and resistance occurred in this case when farmers believed their local knowledge was being disregarded and when science-policy ways of knowing were being given more emphasis than their way of knowing. Furthermore, while science data indicated declining water quality, farmers' experiences, observations and recollections from the past suggested improving water quality in the Manawatu River. Additionally, farmers cannot see the nitrogen leaching from their soils, or the increased leaching to waterways as a result of an intensification and increase in dairying in the region. This lack of agreement contributed to questioning, disbelief, conflict and resistance to the Proposed One Plan. The older farmers' past recollections and historical memories raises an interesting thought: are ways of knowing influenced more by how or by when individuals experience water quality and practice change? Freitag (2014) also pondered this point.

Conclusion

What do these findings mean for policy making processes? How can stakeholders communicate and participate more effectively? A policy process that acknowledges all ways of knowing to be equally valid and reasonable (Brugnach & Ingram, 2012a, 2012b), and one that does not place more emphasis on one type of knowledge above another, is likely to be more collaborative and inclusive. It is also important to think about the overlap and similarities between ways of knowing, rather than thinking of them to be different and divergent with little middle ground. A collaborative process occurs when diversity and difference are embraced, and when overlaps in ways of knowing occur. Looking to the future, Horizons have changed their approach and acknowledge there are a multiplicity of ways of knowing regional freshwater quality. Horizons are designing a collaborative process that will embrace diversity and difference and will encourage overlaps in ways of knowing water quality.

References

Aussiel, O., Barnett, H., Beveridge, A., Fung, L., Gilliland, B., Gordon, F., . . . Zarour, H. (2005). *State of the Environment Report of the Manawatu-Whanganui Region*. New Zealand: Horizons Regional Council.

Ballentine, D. J., & Davies-Colley, R. J. (2009). *Water Quality States and Trends in the Horizons Region*. Hamilton, New Zealand: National Institute of Water and Atmospheric Research Ltd.

Brugnach, M., Dewulf, A., Pahl-Wostl, C., & Taillieu, T. (2008). Toward a Relational Concept of Uncertainty about Knowing Too Little, Knowing Too Differently, and Accepting Not to Know. *Ecology and Society, 13*(2).

Brugnach, M., & Ingram, H. (2012a). Ambiguity: the challenge of knowing and deciding together. *Environmental Science and Policy, 15*, 60-71.

Brugnach, M., & Ingram, H. (2012b). Rethinking the Role of Humans in Water Management: Toward a New Model of Decision-Making. In B. R. Johnston, L. Hiwasaki, I. J. Klaver, A. R. Castillo, & V. Strang (Eds.), *Water, Cultural Diversity, and Global Environmental Change: Emerging Trends, Sustainable Futures?* France: UNESCO.

Collins, H. M. (2018). *Dairy Farmers' Responses to Water Quality Interventions: A Case Study in the Manawatu-Wangnaui Region of New Zealand.* (Doctor of Philosophy), Massey University, New Zealand.

DairyNZ, & DCANZ. (2013). *Sustainable Dairying: Water Accord. A commitment to New Zealand by the dairy sector*. New Zealand: Dairy NZ.

Duncan, R. (2016). Ways of knowing – out-of-sync or incompatible? Framing water quality and farmers’ encounters with science in the regulation of non-point source pollution in the Canterbury region of New Zealand. *Environmental Science & Policy, 55*(1), 151-157.

Feldman, M. S., Khademian, A. M., Ingram, H., & Schneider, A. S. (2006). Ways of Knowing and Inclusive Management Practices. *Public Administration Review, 66*(S1), 89-99.

Fisher, R. K. (2013). ‘A gentleman’s handshake’: The role of social capital and trust in transforming information into usable knowledge. *Journal of Rural Studies, 31*, 13-22.

Fonterra. (2013). *Supply Fonterra. Our Path to a Sustainable Future*. New Zealand: Fonterra Co-operative Group.

Freitag, A. (2014). Naming, Framing, and Blaming: Exploring Ways of Knowing in the Deceptively Simple Question “What is Water Quality?”. *Human Ecology, 42*(2), 325-337.

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied Thematic Analysis*. United Kingdom: Sage Publications.

Horizons Regional Council. (2014). *One Plan. The Consolidated Regional Policy Statement, Regional Plan and Regional Coastal Plan for the Manawatu-Wanganui Region*. New Zealand: Horizons Regional Council.

Horticulture New Zealand V Manawatu-Wanganui Regional Council, NZHC 2492, The High Court of New Zealand Wellington Registry (2013).

Ingram, H., & Lejano, R. (2009). Transitions: transcending multiple ways of knowing water resources in the United States In D. Huitema & S. Meijerink (Eds.), *Water Policy Entrepreneurs: A Research Companion to Water Transitions Around the Globe*. United Kingdom: Edward Elgar Publishing Ltd.

Kasperson, R. E., Golding, D., & Tuler, S. (1992). Social distrust as a factor in siting hazardous facilities and communicating risks. *Journal of Social Issues, 48*(4), 161-187.

McArthur, K. J., & Clark, M. E. (2007). *Nitrogen and phosphorous loads to rivers in the Manawatu-Wanganui Region: An analysis of low flow state. A technical report to support policy development*. New Zealand: Horizons Regional Council.

Ministry for the Environment. (2014). *National Policy Statement for Freshwater Management*. New Zealand: Ministry for the Environment.

O'Leary, Z. (2014). *The essential guide to doing your research project.* (2nd ed.). London: Sage Publications Ltd.

Parkyn, S., Matheson, F., Cooke, J., & Quinn, J. (2002). *Review of the Environmental Effects of Agriculture on Freshwaters. NIWA Client Report FGC02206*.

Parliamentary Commissioner for the Environment. (2013). *Water quality in New Zealand: Land use and nutrient pollution*. Wellington, New Zealand: Parliamentary Commissioner for the Environment.

Robson, C. (2011). *Real World Research. Third Edition*. United Kingdom: John Wiley & Sons Ltd.

Roygard, J. K. F., Hurndell, R., Clark, M. E., & Nicholson, C. (2011). *Overview of Horizons' Surface Water Monitoring Programmes*. New Zealand: Horizons Regional Council.

Smith, C. M., Wilcock, R. J., Vant, W. N., Smith, D. G., & Cooper, A. B. (1993). *Towards sustainable agriculture: freshwater quality in New Zealand and the influence of agriculture. MAF Policy Technical Report 93/10*. New Zealand: MAF Policy.

Snelder, T., Brooker, D., Unwin, M., Wood, S., & Wilcock, B. (2014). *State and Trends of River Water Quality in the Manawatu River Catchment*. New Zealand: Horizons Regional Council.

Stake, R. E. (1995). *The Art of Case Study Research*. United States: Sage Publications Ltd.

Young, R. (2010). *Ecosystem Metabolism in the Manawatu River*. New Zealand: Cawthron Institute.

Young, R., & Clapcott, J. (2010). *Temporal Variability in Ecosystem Metabolism of Rivers in the Manawatu-Whanganui Region - updated. Report No. 1791*. New Zealand: Cawthron Institute.