

## Article

# Drone Use in On-Farm Environmental Compliance: An Investigation of Regulators' Perspectives

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**Abstract:** Freshwater resources around the world are under increasing pressure from agricultural activities. As a result, regulatory frameworks around on-farm environmental compliance have become more complex. Consequently, farm plans which have been used in New Zealand to identify risks to and develop mitigation strategies for freshwater quality can be time consuming and costly to develop and monitor. Using semi-structured interviews, this study investigated the views of the regulators working in environmental policy and implementation on the use of drones to increase the efficiency of on-farm environmental compliance. Results show that drones can improve process robustness by providing an aerial view, and that they are quicker and safer to use on steeper contoured farms. However, there is confusion around the permissions required in order to capture footage, its ownership and storage, and who has access rights to the footage. This ambiguity in the implementation of environmental regulations can lead to uncertainty on the part of policy implementors around how to integrate drones in on-farm environmental compliance. In addition, positive relationships between farmers and compliance officers are needed in order for the benefits of drone use to be realised for on-farm environmental compliance purposes.

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**Keywords:** drones/UAVs; agriculture; auditing; trust; farmer; regulations; environmental compliance

## 1. Introduction

Globally, there is pressure on both the quality [1,2] and quantity [3] of the freshwater resource. Agriculture, as the largest user of fresh water [3], is tasked with increasing food production for a growing population while ensuring the longer-term sustainability of fresh water resources [4]. Fresh water sustainability affects productivity, as well as ecosystems, cultural values, and recreational opportunities [2]. To manage the resource, a majority of countries have introduced and instituted policies at a national level [5]. Pirsoul and Armoudian [6], however, argue that water governance and management are challenging to solve in a 'top down' manner. Critical to the success of these policies is their implementation at 'ground level' and the monitoring and reporting of outcomes in order to generate ownership and transparency, thereby leading to trust in both the policies and their implementation.

These 'ground level' processes can be time consuming, especially considering the large number of farming entities that would need to go through on-farm environmental compliance processes. Can technology help to improve the efficiency of these on-farm processes? From a policy perspective, this study investigates whether drones, an increasingly common technology, can assist with the monitoring and reporting of on-farm environmental outcomes with regards to the sustainability of the fresh water resource.

### *1.1. Policy Instruments*

In order to address the issues surrounding deteriorating fresh water quality, many countries have implemented strategies with the aim of monitoring water quality and reducing the pollution created by agricultural activities. For example, in Australia, where irrigation combined with particular soil types has created widespread issues with salinity, the government has mainly relied on extension along with small grants to landholders; however, this failed to create the required changes [7]. In the EU, a range of economic instruments have been used. One example is the provision of payment for ecosystem services (PES), such as providing in-stream water supply, water purification, maintaining aquatic habitats, and ensuring that water is suitable for recreational purposes [8]. However, the success of PES payments is dependent on the political, sociocultural, and institutional contexts in which they are used.

Thus, different countries have used a mix of policy instruments to manage environmental challenges, including the fresh water resource [9]. Weersink [10] reported three key policy instruments: (1) moral suasion, (2) regulation, and (3) an economic approach. Moral suasion involves persuading an individual or group to act in a certain way. While being relatively inexpensive and popular among producers and regulators, lower levels of farmer participation can result, as evidenced in voluntary agri-environmental schemes [10]. The second instrument is a regulatory approach in which the government mandates a particular behaviour, which can then be enforced by law. While this is simple and direct, it lacks any way to incentivise further change after the standards have been met, and requires adequate resources in order to ensure sufficient compliance. The third instrument is an economic approach, using charges, subsidies, and tradable permits. Where the issue is nonpoint or diffuse pollution, however, such as losses of nutrients, sediments, and pathogens from agriculture [1], it is not possible to change behaviour through economic instruments [10]. This leaves moral suasion and regulation as the key policy instruments, perhaps with greater effectiveness if used in combination rather than in a stand-alone approach.

### *1.2. Regulatory Approach*

As in most countries with significant levels of agriculture, New Zealand waterways are being threatened by excess nutrients, pathogens, and sediment, to the extent that many water sources are no longer safe for drinking and recreation [11]. The Ministry for the Environment and Statistics New Zealand [11] noted that 82% of river length in pastoral areas has modelled pathogen levels unsafe for swimming. To address this pollution, certain regulatory frameworks have been put into place.

In contrast to other countries, such as the UK, New Zealand has historically had a 'light touch approach' with regard to environmental regulation of the agricultural sector [12]. Following the neoliberal reforms of the 1980s, the central government has had relatively little input into land management, leaving decisions to farmers [13]; this has resulted in low levels of monitoring and reporting of environmental outcomes at the farm level. The light touch or laissez-faire approach typically leads to externalities with costs or benefits accruing to third parties [8]. Due to concerns surrounding the quality of fresh water, the National Statement for Freshwater Management Policy was introduced in 2011. While this policy was developed at the national level, it was implemented at the regional level by Regional Councils and Unitary Authorities (RC). The major transition was movement of the RCs from an educational approach to working with farmers to a more regulated approach [14,15]. Despite this, and despite a further strengthening of the fresh water standards, fresh water quality has continued to decline in New Zealand [11]. In response, in 2020 the central government developed the National Policy Statement for Freshwater Management, which set out the objectives and policies for fresh water management under the Resource Management Act of 1991 [16]. The resulting suite of regulations became the

basis for developing and implementing regulations at the regional level, with the responsibility for monitoring and reporting falling to the RCs.

### *1.3. Farm Plans*

Under the National Policy Statement for Freshwater Management, all farmed land over 20 ha for arable or pastoral use needs a Freshwater Farm Plan (FWFP), with the expected rollout starting in early 2023 [17]. The aim of the FWFPs is to assist farmers in identifying potential sources of pollution and developing strategies to manage these risks. The process of developing and monitoring these FWFPs is intended to encourage a sense of ownership on the farmers' part, resulting in a higher likelihood of positive environmental outcomes [18]. A predecessor of the FWFPs are Farm Environment Plans (FEPs), which have been used for regulatory purposes in the agricultural sector in selected regions of New Zealand. For example, FEPs have been used by Environment Canterbury (ECan) in Canterbury in an attempt to manage nutrient runoff from dairy farms, thereby reducing their impact on fresh water quality [19].

The transition from FEPs in selected regions to FWFPs country-wide presents challenges in both the monitoring and reporting of environmental outcomes. First, auditors need an in-depth understanding of a range of farming systems, environmental regulations, and how the regulations can be applied in farming practice. Second, auditors need to be able to build strong and positive professional relationships with farmers, which can be challenging when applying regulations [19]. Finally, auditing farm plans is time consuming, both on a regional and individual farm basis. For example, in Canterbury, FEP audits are conducted in six stages, with all except the first and last stages conducted on a two-to-three-hour farm visit [19]. With FWFPs expected to follow a similar process, and considering that the number of farms that requiring FWFP audits in order to meet the National Environmental Standards for Freshwater was estimated at 49,530 in 2021 [20], the colossal amount of time required is more than a little daunting, highlighting the need for efficient processes.

### *1.4. Approaches to Increase the Efficiency of Auditing*

In New Zealand, several approaches have been utilised to increase the efficiency of environmental compliance, i.e., auditing FEPs. In Canterbury, farmers have been graded on their farm audit, with those achieving higher grades audited less often [21]. Several RCs have used contractors for the auditing process, with farmers able to employ their own auditor chosen from a list of auditors approved by the RC who then completes the audit on behalf of the RC [22]. While contracting out reduces the auditing burden for the RC, it does not alter the time-consuming nature of the process. Elsewhere, 'online' auditing, in which the farmer uploads information to an online portal and a phone conversation between auditor and farmer replaces the on-farm visit, has been trialled as well [23]; however the validity and reliability of the uploaded information remains questionable. Regardless of these different approaches, RCs need to provide clear policies in order to guide the processes that farmers and rural professionals are meant to follow.

This leads to the question of how can RCs manage the audit process effectively and whether technology such as drones could be used to assist. Drones, or UAVs, have been increasingly used in agriculture for tasks such as spraying [24], moving livestock [25], and monitoring crop health [26]. With regard to environmental monitoring, they have been used to find point source pollution [27] in forestry management [28,29], and are being developed to monitor air pollution [30].

In a previous study, we investigated the views of farmers and rural professionals regarding drone use in FEP audits [19]. Both farmers and rural professionals acknowledged the value of an aerial perspective and cost efficiencies compared to driving around on-farm, particularly for large scale operations. Limitations caused by unfavourable flying conditions such as high wind and rain were acknowledged. The key enabler, however, allowing the advantages of drone use to be realised was the farmer–auditor relationship.

This reflected farmers' reliance on interaction-based trust with their rural professional as a result of the perceived confusion surrounding the rules and regulations relating to environmental management on-farm in New Zealand [19]. This discovery motivates us to investigate the perspectives of policy-makers and implementers in relation to drone use in on-farm environmental compliance in New Zealand, which has become even more important to investigate in light of the upcoming country-wide changes in FWFPs.

### *1.5. Research Focus and Questions*

The focus of this study was to investigate the perceptions of those working within regional government, policy, and implementation on the potential role of drones in on-farm environmental management and compliance. The specific research questions were as follows:

1. What are the potential benefits and limitations of using drones for the purpose of on-farm environmental compliance?
2. What does the institutional environment look like to take advantage of drone use for on-farm environmental compliance purposes?

## **2. Materials and Methods**

An inductive-led theory-building methodological approach [31,32] was utilised due to the novel research area (the use of drones in on-farm environmental compliance processes) and the relative lack of scholarly work in the area. Following the principles of selective sampling and theoretical sampling, semi-structured interviews were conducted with twelve participants [33]. This was for the purpose of obtaining rich data from multiple RCs, and hence on a variety of environmental conditions for farming, across New Zealand.

### *2.1. Study Area*

The RCs included in this research were those of Southland, Otago, Canterbury, West Coast in the South Island, and Manawatu–Whanganui in the North Island (underlined in Figure 1). These areas illustrate the diversity of landforms and water issues across New Zealand. For example, Southland, a relatively flat area with fertile soils and reliable rainfall, is a key dairy farming region in New Zealand [20]. The increase in dairy cow numbers since the 1990s has caused deterioration in the waterways, and actions have been undertaken to mitigate this negative impact of dairying [34]. In contrast, the West Coast Regional Council has lower numbers of dairy cows and sheep [20]; it covers a long (600 km) and thin strip of coastal land, and is subject to heavy rainfall and poorly drained soils [35]. Canterbury has flat and well-drained arable land that supports dairying and sheep farming [20]. However, due to the prevailing drying northwest foehn winds [36], the region relies on extensive use of irrigation, which brings with it associated environmental issues such as nitrate leaching [37]. Both Otago and Whanganui–Manawatu have a mix of sheep and dairying. It should be noted that all New Zealand regional councils are facing pressures with regard to land and water [38].



**Figure 1.** NZ Regional Councils and Territorial Authorities (adapted from Creative Commons).

## 2.2. Research Methods

Following an inductive-led theory-building methodological approach, we adopted the use of vignettes as a medium of communication for the interviews. A vignette is a short hypothetical scenario presented to research participants. It helps to frame the questions in order to reveal participants' perceptions, values, social norms, or impressions [39]. Vignettes allow the contextually rich circumstances that are analogous to real-world situations be presented to participants [40]. Such a contextual richness has a positive impact on people's ability to solve problems compared to those in situations that are presented in an abstract manner [41]. Lanza, et al. [42] considered that responses to vignettes reflect responses to real world situations. Considering the diverse backgrounds of the participants, who work in multiple government organisations and may or may not be familiar with farming, vignettes were considered in order to provide conversation platforms that could reduce the differences between participants due to their preconceived ideas about farming practices and related environmental topics, thereby strengthening the validity and reliability of the research findings. Two vignettes were employed in the present research to facilitate the conversations with participants. Researchers followed the principles of vignette design suggested by Evans, et al. [43], in which different levels of the independent variables are operationalised as different conditions (vignettes) and presented

to research participants. Specifically, we adopted a within-subject design, in which a set of multiple vignettes were presented to all participants followed by open-ended questions [39]. Details of these vignettes and the two scenarios under which they were presented are explained in Section 2.4. (Research Process).

### 2.3. Participants

Participants were recruited from the central and regional government by the researchers' own networks and via snowballing from (Table 1). Interviews continued until the data saturation point was reached. Participants' willingness to participate in the project was the only criterion required for informant recruitment. Eight interviews involving twelve participants were conducted between 21 March and 3 May 2022.

**Table 1.** Description of participants.

ID	Level	Region	Number of Interviewees	Role
1	Central	NZ (Ministry for the Environment or MFE)	1	Policy
2, 3	Regional	Canterbury (ECan)	2	Drone technical × 1, Compliance × 1
4, 5	Regional	Manawatu-Wanganui (Horizons)	2	Farm systems × 1, Compliance × 1
6	Regional	Canterbury (ECan)	1	Legal
7	Regional	Southland	1	Compliance
8	Regional	West Coast	1	Compliance
9	Regional	Otago	1	Compliance
10, 11, 12	Regional	Canterbury (ECan)	3	Farm systems × 1, Compliance × 2

One interviewee worked for the central government, while the remainder worked with RCs: three with ECan and one each with Otago Regional Council, Environment Southland, West Coast Regional Council, and Horizons (the name of the Regional Council for Manuwatu–Wanganui). For all of the interviews with RC staff, all of the participants were working in the areas of compliance, legal, or providing advice to farmers. In each of the interviews, one of the participants had experience with drone use. One participant had a professional qualification to fly a drone. The participants had very diverse backgrounds. Their university degrees involved either agriculture or the environment. One participant was a farmer, and two had previous careers in the police force, where their experience in enforcement was valued.

### 2.4. Research Process

Semi-structured interviews with the participants were conducted online and face to face. Interviews took approximately 60 min. The first section of the interview focused on ascertaining participants' understanding of the on-farm environmental audit process. This was followed by using Scenario 1 (Figure 2) to explore participants' views on the use of drones in the process. Specifically, Scenario 1 was used to explore the advantages and disadvantages of using drones in the compliance process in an extensive (Tom's situation) and an intensive (Sally's situation) farming context and what the respective advantages and disadvantages could entail for policy implementation.

**The situation:** Drones or UAVs are becoming more widely used for on-farm auditing for environmental compliance. This involves replacing part of the farm tour with flying a drone and viewing live footage and taking digital images. Where potential problems are identified, an on-site visit to the location of interest is followed through, along with a discussion with the farmer regarding the issue identified.

Consider the following two individual farmers, Tom and Sally, who are managing the following farms:

**Tom** - an extensive, sheep/beef/deer, large scale, hill farm

**Sally** - an intensive, dairy support and cropping, smaller scale, flat farm

**Figure 2.** Scenario 1, exploring participants' views on the use of drones in the audit process.

Scenario 2 was then used to explore participants' views of the farmer–auditor relationship and drone use (Figure 3). Participants were asked how the different situations faced by Mary, Ace, and Ben could influence the effectiveness of the drone use in the on-farm audit. In addition, participants were asked whether they believed Ben's situation could be feasible in the future. Participants' views on who should own, have access to, and store any drone footage collected during the audit were explored.

**The situation:** Following on from the situations in **Scenario #1**, consider three individual farmers, Mary, Ace and Ben, and the following information:

**Mary** – does not know of an auditor who will undertake the audit process.



**Ace** – has a strong, positive professional relationship with an auditor who will undertake the compliance process including taking aerial footage with a drone.



**Ben** – will take aerial footage himself using a drone and upload this and any other required information to an on-line compliance portal.



**Figure 3.** Scenario 2, exploring participants' views on the auditor–farmer relationship.

### 2.5. Data Processing and Analysis

Interviews were recorded, then transcribed and imported into NVivo12 Plus along with detailed notes. This was followed by coding for thematic analysis [44]. Nodes were formed based on ideas from the interview process described in this section. The coder remained alert for additional themes or codes that may have emerged from the data. Whenever a new theme emerged, the coder conducted a review of the already-coded text to ensure the internal validity of the results. To improve rigour, the coder and researchers regularly discussed the coding in order to triangulate the 'emerged themes'.

### 3. Results

Overall, drones were viewed as a potential tool to assist in on-farm environmental management, as described by Participant 9: *“Nothing beats boots on the ground and talking to people ... But sometimes I can see drones have the benefit.”* In terms of the processes which drones could be used for, there was agreement that they could be useful for compiling farm maps, which could then be used in a farm environment plan. However, there was disagreement around their use in auditing and compliance processes. One participant was concerned that farmers may not accept drones being used in the processes, as Participant 1 reported *“the majority of farmers would probably shoot the drone before they’d ask questions.”* Another participant, however, reported that flying a drone over a property would be the most efficient way for farmers to demonstrate environmental improvements made to their farms.

#### 3.1. Benefits of Using Drones

Three key benefits of using a drone in on-farm environmental management emerged from the data. The first was that a drone could provide an aerial view of key areas of interest on the farm, thereby improving the robustness of the data gathering for the processes. Yet, gathering an aerial view was reported as a disadvantage for farmers, as the compliance officer could investigate more areas of interest on a farm than possible when driving around the farm in a vehicle. This might lead to an audit taking longer, decreasing the efficiency of the audit process, as described by Participant 10: *“It’s a disadvantage to the farmer in that it will reduce efficiency because then auditors will look at more things than they would have seen otherwise but it’s also advantage to the robustness of the programme because it means more stuff is being checked but it’s where that balance is.”*

The remaining benefits related to larger-scale properties and/or farms with a steeper land contour. Flying a drone around these types of farms could be both safer and less expensive, as less fuel would be used than the traditional drive around the farm.

#### 3.2. Concerns over Using Drones

The need for new council procedures and for trained and experienced drone pilots, leading to added costs, was reported as a disadvantage of using the technology by Participant 9: *“No one can fly a Council operated drone unless they’ve passed that training... There’d have to be standard operating procedures.”*

Participants identified three main areas of concerns regarding drone use for environmental compliance purposes: (1) permission to capture footage, (2) ownership and storage of the footage, and (3) who would have access rights to the footage.

First, the permission of the farmer and any other person whose image could be captured in the footage would need to be gained before the drone could be used in on-farm compliance processes. Whether or not permission was granted depended on a positive professional relationship, and in particular on the level of trust, between the compliance officer and farmer, as illustrated by Participant 9 in Table 2. If the drone is used to capture footage for monitoring purposes, however, Participant 2 reported (Table 2) that they have the legal right to use a drone to capture footage to assist with their investigation, and the farmer’s permission to fly the drone is not required.



**Table 2.** Concerns over drone use for environmental compliance purposes.

Theme	Sub Theme	Quotes
Permission to capture drone footage	Auditing	(Participant 9) Images speak 1000 words. If you've got winter grazing, and you've got aerial footage, you've got to be able to get it legitimately, use it and store it properly. ...that's building trust.
	Monitoring vs auditing	(Participant 3) With auditors, if they want to use a drone on a farm, they would need to get permission from the farmer...under our warrant under Section 3.3.2 [of the legislation that we operate under]. we can take a drone on whether the farmer likes it or not.
Ownership and storage of footage	Regional council	(Participant 10) The auditors taking their footage on behalf of the Council, so, the Council has a responsibility for owning that footage and securing that footage.
	Farmer or drone owner	(Participant 4) It belongs to the farmer. Well, it belongs to the person who took it.
Access to the footage	Farmer only access	(Participant 9) There's no reason for them to pass that imagery onto anyone else, bar the farmer.
	Public access	(Participant 1) It's not often explained to a farmer up front. Everything that's done through regional council processes is discoverable.
	Risks of public access	(Participant 8) That's why there's no personal information goes out with it. Otherwise, there's activists and stuff that play the system.
	Legality	(Participant 1) [Footage] cannot be LGOIMA-ed because it is not consent-based so it's private information...if it's a compliance-related action using a drone for footage... as soon as that council officer does it, it's discoverable because its RC information

A second underlying cause limiting drone use in on-farm environmental compliance was confusion surrounding who owns and is responsible for storing the footage. One view was that as audits and compliance are undertaken on behalf of a RC, the Council then owned and had responsibility for storing the footage, as described by Participant 10 in Table 2. RC ownership of the footage then had implications with regard to who could access the footage. However, another participant believed that either the farmer or the drone pilot owned the footage.

Ownership and storage of the footage leads to the third concern surrounding drone use in on-farm environmental compliance, namely, who would have the right to access the footage. There was a belief that footage held by the RC only needed to be shared with the farmer on whose farm the footage was taken (Participant 4, Table 2). However, other participants pointed out that any information held by councils was deemed to be public information, and thus discoverable as governed by legislation, specifically the Local Government Official Information and Meetings Act 1987 (LGOIMA) [45]. This could lead to potential risks, as explained by Participant 1 in Table 2. RCs have additional processes, such as ensuring that no personal information is captured in the footage, or using still photographs rather than video of specific areas of interest, to manage the risks surrounding public access. These additional steps could potentially limit the use of drones in auditing processes.

### 3.3. Fostering Professional Relationship Conditions for Drone Use

In order to take advantage of drone usage, participants indicated that it was important to build a positive professional relationship with farmers. This could encourage farmers to reach out to compliance officers for assistance with environmental management and foster compliance with regulations. The effect of a positive professional relationship between a compliance officer and farmers was described by Participant 7: "it's very hard to get full compliance all the time if you're very militant and rigid. You need to

be able to be sympathetic, understand their point of view.” A positive professional relationship was considered a pre-requisite for obtaining farmers’ permission to fly a drone over their property, as outlined in Section 3.2 (Concerns over Using Drones). There was, however, a query as to whether RC compliance officers could in practice have a positive professional relationship with farmers due to the nature of their work. In this case, the option to use drones by compliance officers could be mandated in RC regulations, as described by Participant 1: “But if it’s a council-based auditor, they’re not going to usually have that relationship. So, to be given the mandate to utilise a drone for compliance actions, it’s got to be written into the Regional Council’s policy.”

The type of relationship built between the compliance officer and the farmer is underpinned by the overall approach of RCs to working with farmers. Participants reported that RCs take an educational approach to working with farmers, as this provides a more effective way of achieving on-farm environmental change. An enforcement approach was only utilised after an educational approach had been exhausted. This sequence of approaches was described by Participant 4: “I think it might change by regional council, but we’ll be going there for more of an education point of view, first off, but if there’s anything really, really, really bad then.” An RC’s educational approach was enabled by a positive professional relationship between the compliance officer and the farmer, as well as vice versa. Participants reported that this relationship could be enhanced in several different ways.

First, certain participants believed that this professional relationship could be enhanced by allowing farmers to select their compliance officer from a pre-approved list provided by the RC. These compliance officers would be paid directly by the farmers and contracted to the RC. However, while this allowed farmers to have a degree of choice and could enhance a positive professional relationship, an alternative view was that it provided too much choice. Other participants believed that, provided RCs employed appropriate staff, a positive relationship should be able to be built between them and farmers. This was described by Participant 8: “To choose your own auditor, it’s a bit of pandering ... Whereas if you just had decent people to do the job, it wouldn’t be hard for anyone to sort of object to you.”

Second, participants suggested that compliance officers spend time in specific farming region in order to allow time for a positive relationship to develop, as described by Participant 8: “We employ people, and we don’t swap areas every three years. You generally stay in your area because you know you can handle the farmers. Once you know a farmer you can generally talk them around to getting something done.” However, retaining staff in a particular region for the medium-to-long term can be challenging as staff move onto other roles both within and outside the RC. This was described by Participant 5: “There’s like a two-year average... then move onto another role in council somewhere else. So, that is usually something that does come up. It’s always a different person who comes out.”

The third suggestion to enhance the farmer–compliance officer relationship was by having auditors with experience of farming, or skills and knowledge that farmers considered useful, as described by Participant 7: “I’ve got an extensive farming background so it’s easier for me to relate ... their whole attitude towards me will change.”

The fourth way to enhance the relationship was to spend time with individual farmers, discussing aspects of environmental management such as the environmental requirements and options to meet the regulations. However, participants reported that the time spent developing a relationship needed to be balanced with getting the job done, as described by Participant 7: “That’s important to us, building that relationship. At the same time, you manage it because you still need to do a job.”

Overall, while a positive professional relationship with farmers was a key aspect for obtaining buy-in for on-farm environmental compliance and encouraging farmers to meet environmental regulations, building a positive relationship needs to be accompanied by a high level of professionalism, as challenging decisions with regards to a farmer and their

environmental management may have to be made. Participant 9 described this point: “We come back to level of trust and professionalism... you would hope that there isn't any form of favouritism or blind eye turning or whatever it is.”

#### 4. Discussion

The results of the present investigation indicate that there are clear advantages of using drones in on-farm compliance processes. However, policy-makers/implementers indicated concerns around drone use with regard to ownership, privacy, and access. These could cause confusion for farmers and others involved with the compliance process. The sources of confusion lie within the ambiguity surrounding the implementation of environmental compliance regulations. This ambiguity fundamentally drives the reliance on building trusting relationships with those who farmers interact with during the compliance processes.

##### 4.1. Ambiguity Surrounding the Implementation of Compliance Regulations

Concerns over drone use raised by regulators reflected a level of uncertainty within the implementation of regulations involving on-farm environmental management. The questions of (1) whether or not compliance officers have the legal permission to take drone images and (2) who owns the images, along with the linked question of (3) who has the right to access the images all received different answers from regulators from various RCs and the central government. This inconsistency in the answers reveals a lack of clarity, and as such a source of confusion for both farmers and the regulators themselves. This confusion is even more aggravated when still images can imply a different level of privacy protection compared to video footage, as explained in Section 3.2 (Concerns over Drone Use).

This lack of clarity is partly caused by the fact that different regional councils across New Zealand appear to have taken varied approaches towards environmental compliance in farming. While all take an educational approach (the carrot) followed by an enforcement approach (the stick), RCs place different weights on these approaches. Effectively, different regional councils utilise varied mixes of the three instruments referred to by Weersink [10], while aiming for a similar outcome of improved environmental practices in farming. This variation reflects the legal framework functioning within New Zealand, where the central government sets policy statements and then regional councils are tasked with their interpretation. While this autonomy of interpretation allows each regional council to tailor their policy implementation to suit their own geographic, biophysical, and socioeconomic environments, it creates a sense of uncertainty and confusion among the parties involved with environmental compliance in farming.

##### 4.1.1. Technology Progress and Regulation Not Keeping Up

Another possible reason for the ambiguity or lack of clarity around environmental regulation in relation to drone use is possibly a reflection of the fact that New Zealand's environmental regulations have not been able to keep up with the fast development of drone technologies. Drone technologies have developed at such a speed over the last decades that high resolution images and artificial intelligence can be practically used by tech-savvy farmers and rural professionals [19]. Nevertheless, what drones are capable of, and subsequently what regulatory implications these capabilities create, need to be considered in the implementation of regulations associated with compliance. Additionally, if compliance officers were to utilize the advantage of drones, then many would need to upskill by learning to be capable drone pilots, with the training itself incurring costs.

##### 4.1.2. Sources of Confusion for Farmers

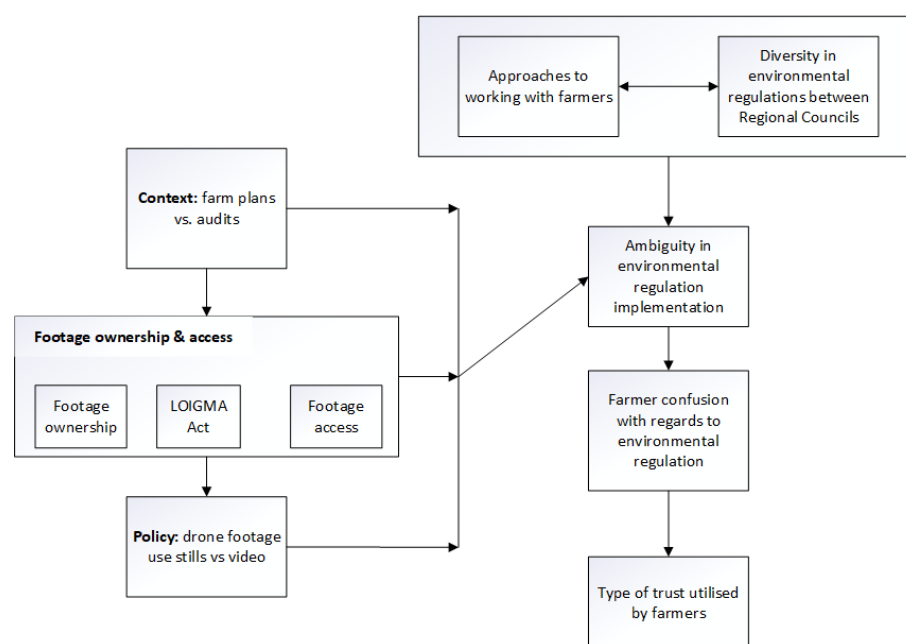
The ambiguity in the regulatory environment surrounding drone use in relation to farm environmental compliance is a source of confusion for farmers. This is particularly

the case for those working on farms or farming corporates that cross regional boundaries, as different rules are effectively applied to the same operation. Thus, farmers prefer to work with those who they trust or can develop trusting relationships with in order to gain a level of certainty within their farming operations for environmental compliance purposes. These entrusted individuals tend to be those who have direct contact with farmers in relation to farm environmental compliance, ranging from independent auditors to environmental compliance officers from regional councils, although less likely to be the latter due to the power imbalance perceived by farmers [19].

#### 4.2. Farmers' Reliance on Professional Relationships and Implications for Trust

Farmers' reliance on relationships with those who they trust instead of the regulatory framework surrounding environmental compliance is the result of ambiguity in the implementation of regulations. This confirms the finding of previous research by Lucock and Westbrooke [19], in which they found that farmers resort to interaction-based trust when institutions are vague and institutional-based trust cannot be relied on [46,47]. The present research has been able to uncover possible sources for the ambiguity of such institutions, in particular the freedom or autonomy of various regional councils in choosing a 'carrot' or 'stick' approach when interpreting national policies in order to suit the varied circumstances of each region, which can result in confusion. If better environmental outcomes through behavioural change on the part of farmers is the ultimate goal of environmental regulation, then greater clarity is required to give farmers confidence about the regulatory environment that they operate within. As Knook, Dynes, Pinxterhuis, de Klein, Eory, Brander and Moran [12] discovered around the diffusion of water pollution, in countries with a light-touch approach to regulation such as New Zealand, "certainty around policy and also around the effectiveness of practices is essential, particularly for farmers who delay action until compelled to act due to succession or regulation."

The complex causal links from lack of clarity surrounding the implementation of regulations through to the type of trust that farmers employ in relation to drone use in environmental compliance is depicted in Figure 4 below.



**Figure 4.** Causal links from lack of clarity surrounding implementation of regulations through to the type of trust that farmers employed in relation to drone use in environmental compliance.

#### *4.3. Looking into the Future: Compliance Processes*

As farming in New Zealand and around the world progresses into a future with increasing environmental challenges, regulators are seeking more effective measures to encourage compliance that can lead to better environmental outcomes. In New Zealand, Freshwater Farm Plans (FWFPs) are due to roll out by the end of 2025 in selected regions, with the expectation that these plans will be implemented across the nation by the end of 2035 [17]. The sheer number of farms needing to implement such plans within this timeframe provides a good incentive for regulators to be as efficient as they can, signalling that technologies such as drones could be utilised if appropriate measures are put in place. Considering the legal framework within New Zealand, it is likely that both 'carrot' and 'stick' approaches will be employed by various regional councils. However, as revealed by the present research, a level of certainty and consistency around the use of drones in environmental compliance and FWFPs would be required in order to reduce vagueness and the confusion of all parties involved, especially where modern technologies such as drones are being incorporated.

#### *4.4. Use of Vignettes in Research Process*

Another valuable result of the present research involves the effectiveness of the research methodology and methods employed in understanding the policy-makers' and implementors' perspectives. The benefits are three-fold: (1) the vignettes used in the present research provided a context for the research participants, which was particularly helpful for participants with little knowledge of farming; (2) the photos of various farm scenarios, including farmers' names, stimulated the conversations between the interviewer and the interviewees because the discussion points appeared real; and (3) by using the same hypothetical scenarios with all research participants, the commonality of the discussion points were maintained and presumptions due to personal biases were reduced, strengthening the internal validity of the research findings.

### **5. Conclusions**

Our research concludes that, within the New Zealand context, regulators think that drones can be very useful tools for environmental management, monitoring, and compliance. Regardless of whether a 'carrot', 'stick', or mixed approach is used, trust is necessary in order to ultimately achieve greater efficiency using drones in environmental compliance as desired by the policy-makers. Additionally, while 'carrots', 'sticks', and 'coins' can all be used as instruments for environmental compliance purposes, it is critical to provide consistency and certainty on the rules around implementation across various regions of the country to reduce ambiguity and consequential confusion, thereby facilitating the efficacy of the relevant policies.

To understand the causes of the ambiguity surrounding policy implementation, an area that could be worthy of exploration is the processes of interpreting national policies employed by the regional governments. In other words, on what basis and through what processes are the policies issued by the Central Government being interpreted by the RCs, and how do these interpretations then turn into implementation measures that are directly applied to the farming communities? An in-depth understanding of such processes can help to enlighten researchers on the critical transition from policy-making to policy implementation on the ground, thereby identifying areas of improvement for better efficacy of the policies. As technologies such as drones continue to develop, environmental policies need to evolve with time. A greater understanding of the policy-making to policy implementation transition can facilitate the integration of new technologies such as drones, resulting in more effective and efficient environmental management.

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