Educational Water Trading Games
Simulation software and Future Potential

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1. Introduction

This document summarizes the design of an educational water trading game. The intention of the game is to educate participants about how regulations for fresh water quality and quantity might function. The trading game was developed to help establish a dialogue between the users of fresh water: farmers and firm managers, and the regulators of fresh water: local government and councils.

Two versions of the educational game were developed, each for separate locations in New Zealand. The Hawkes Bay version of the game focuses on the seasonality of water availability; participants must manage irrigation on their farms in each half of the year. The Upper Waikato version of the game focuses on the interaction between the quantity of water taken for irrigation and the quality of water; participants manage consents for both water take and nutrient loss.

We first discuss the simulation platform used to run the games. This is a computer based platform, requiring each participant (and the simulation manager) to have access to a computer. Second, we describe the scenarios that were developed to run on the simulation platform. These scenarios are broken into three sessions for each location, with each session focusing on a different aspect of water regulation.

2. Platform Design

The simulation platform was developed in Microsoft Excel. This software was chosen as it is familiar to a wide range of people and installed on most computers. It makes use of Excel's in-built formulae and cell links. Where necessary ActiveX controls are written using VBA. We built two versions, one for Hawkes Bay and one for the Upper Waikato. Differences are noted where relevant.

The completed platform consists of: **the control file**, from which the simulation manager runs the session; **a hub**, which acts as a centralized location for data transfer; and **ten client files**, one for each (farm) property. Each participant in the simulation is assigned a client file. This file contains a simple model of their property and all the controls they need to manage their property.

The simulation platform was designed according to the following principles:

- Easy to use and learn
    - Minimal complexity

    - Clarity of layout and information
    - Tools to aid decision making
- Scenario capability
    - Adjustable for different scenarios / sessions
    - Sufficient complexity
- Technically Sound
    - Timely and accurate data transfer between files
    - Robust (difficult to break)
    - Centralized control

Obviously some of these principles must be balanced with other principles. The platform needed to be sufficiently complex so that it could easily incorporate different designs of scenarios (including multi-round scenarios) while still being straightforward for participants to learn and use. We are satisfied with the balance our platform achieved between the different design principles.

These design principles directly influenced the simulation design. Below we discuss seven key aspects of the simulation design.

1. Each round, participants select the production intensity for their property (or investment decisions in case of the local council or farm – such as a pulp mill), based on what allowances they have.
2. Farmer participants are able to change land use for their properties (at a conversion cost). Each farmer has a choice of three land uses, two whose production intensity varies with water use (and nutrient discharge for the Upper Waikato version) and one that does not (an exit option, frequently forestry).
3. Each farm has a single block of land (i.e. only one land use at a time). With multiple blocks of land, a participant can in effect "trade with themselves" by moving water between blocks of land. In theory there is no difference between two blocks of land managed by one participant and two blocks of land, each managed by one participant. However, giving two participants one block of land each clarifies the trading decision.
4. By default, the platform uses bilateral trading. Participants seeking to trade allowances are required to ask around in order to find an interested trading partner. Where possible this process is supplemented by a physical bulletin board where participants can display offers to buy and sell. Participants record trades on paper

forms and submit these to the simulation manager, who enters them into the control file.

5. By default, each scenario runs for only a single round, with each scenario being independent of the previous one (no carry over or permanent trades). This approach was taken as many of the issues we were interested in could be sufficiently explored / experienced in a single round simulation.
6. The platform enforces compliance. Participants have to be in compliance with their allowance allocations in order to conclude each round.
7. The platform provides summary information at the end of each round. Each participant has a summary of their property saved to their user interface and the aggregated performance of all participants is reported via the master control file. For each round the summary includes: allowance allocations, water use, nutrient use, river condition, profit, trading volumes and prices, land use.

In the remainder of this section we first discuss some of the design elements common to both platforms before discussing the platform for each catchment separately.

2.1. The user interface

We focus our discussion on the user interface aspect of the simulation platform as this is the aspect of the platform that participants see and interact with. The master control and hub files are the other key element of the platform. We discuss these separately.

The following figures give the user interface for each platform.

Figure: Hawkes Bay User Interface

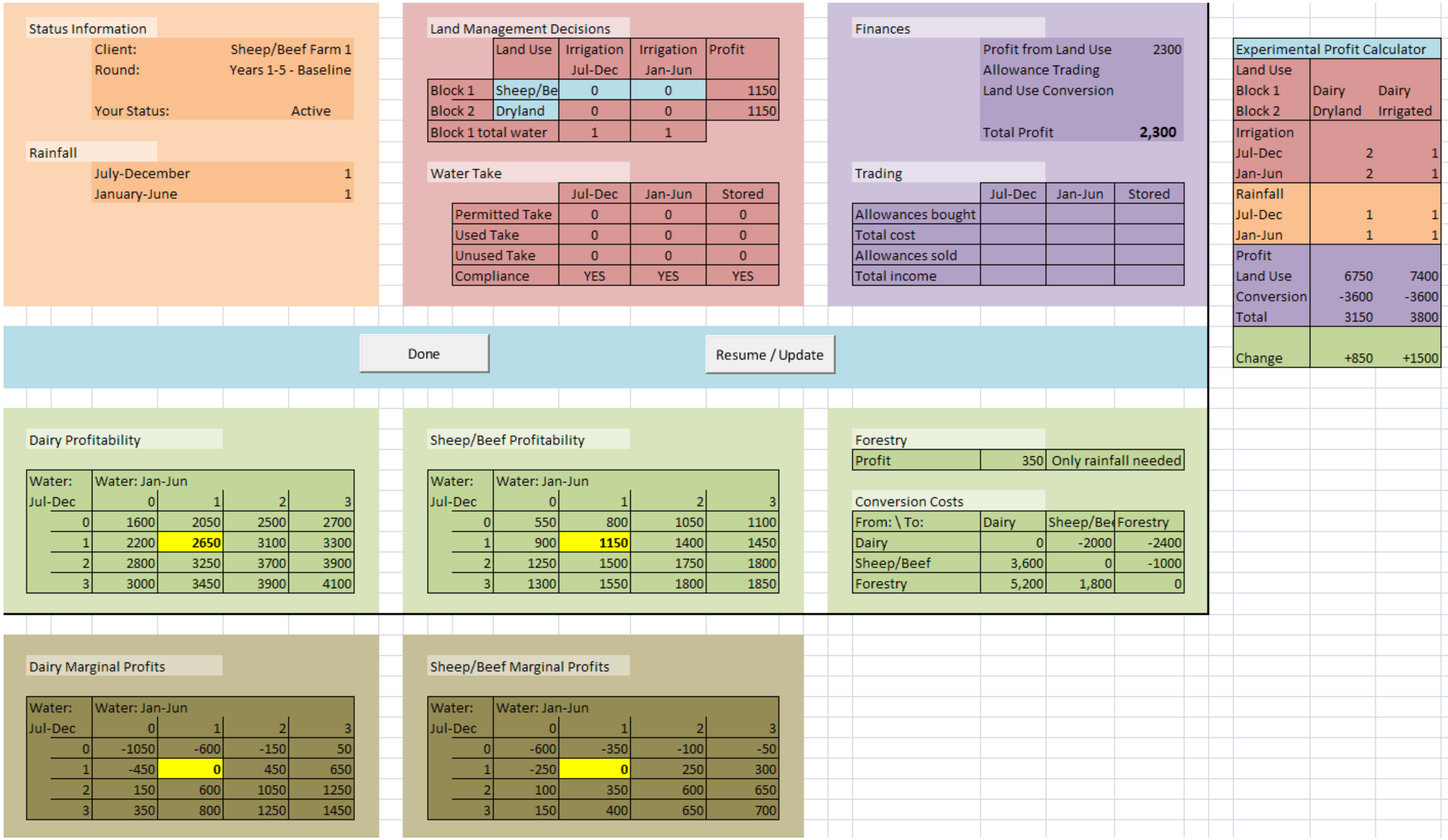


Figure: Upper Waikato User Interface

Status Information

Client:	Dairy farm 1
Round:	1 - Years 1-5 - Business as usual
Location:	Lower Catchment
Your Status:	Active

Best Practice Discharges

Phosphorus	1
Nitrogen	40

Land Management Decisions

Land Use	Production System	Profit
Dairy B.P.	3	3600

Consents

	Water	Phosphorus	Nitrogen
Permitted	1	NA	NA
Current	1	1.1	40
Compliance	YES	YES	YES
Surplus	0	NA	NA
Shortfall	0	NA	NA

Finances

Profit from Land Use	3600
Allowance Trading	
Land Use Conversion Charges	
Total Profit	**3,600**

Trading

	Water	Phosphoru	Nitrogen
Allowances bought			
Total cost			
Allowances sold			
Total income			

Experimental Profit Calculator

Land Use	Dairy B.P.	Arable
Production Intensity	6	1
Water	3	0
Phosphorus	1.6	0.3
Nitrogen	60	20
Profit		
Land Use	4300	700
Conversion	0	500
Total	4300	1200
Change	+700	-2400
Surplus		
Water	0	1
Phosphorus	NA	NA
Nitrogen	NA	NA
Shortfall		
Water	2	0
Phosphorus	NA	NA
Nitrogen	NA	NA

Done / Resume | Update

Dairy Best Practice Profitability

Intensity	Water	Phosphor	Nitrogen	Profit
6	3	1.6	60	4300
5	2	1.4	60	4200
4	2	1.3	60	4100
3	1	1.1	40	3600
2	1	1.0	40	3000
1	0	0.9	40	2200

Arable

Intensity	Water	Phosphorus	Nitrogen	Profit
6	3	1.0	40	2500
5	2	0.8	40	2300
4	2	0.8	30	2200
3	2	0.7	30	2000
2	1	0.5	30	1600
1	0	0.3	20	700

Forestry Profitability

Water	Phosphor	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Forestry
Dairy B.P.	0	-500	-1000
Arable	1,000	0	-200
Forestry	2,000	1,200	0

The different sections of the user interface are as follows:

- Status information (orange):
  Contains information on the farm's location, name, and current status (active or waiting). For Hawkes Bay, rainfall (or expected rainfall) is also reported here. For scenarios involving charges or on-farm nutrient limits, the appropriate values are reported here.
- Management decisions (red):
  Contains the property's current management decisions, allowance holdings and compliance with regulation. Cells for participants to enter their management choices are coloured blue to identify them. Where a participant was not compliant, or has unused allowances, these cells where highlighted yellow to attract attention.
- Finances (purple):
  Contains a summary of the property's earnings and trades for the current period. Total profit includes production profit, conversion costs and any revenue or expenses from trading. During simulations, the trading summary updates once a trade has been inputted and saved via the master control.
- Profit schedules (green):
  Contains three profit schedules and a table giving conversion costs. For Hawkes Bay the profit schedules are 4-by-4 grids where water use in each period determines the return from farming. For Upper Waikato the profit schedules are a 6 option table. The profit values and conversion costs are annualized per hectare values.
- Buttons (blue):
  Contains two buttons: Each round participants clicks the "Done" button once they have made their production decisions, to indicate to the simulation manager that they are ready for the round to conclude. The participant clicks the "Update" button to update their interface with new trades, and to start a new round. One of the two buttons is also labelled "Resume", this has the reverse effect of the "Done" button.
- Decision-support tools (brown and far right):
  Both user interfaces contain decision support tools.
  - To the right of the main interface is an experimental calculator. This is effectively a condensed version of the main interface. Participants are encouraged to trial ideas in this section. Two experiments can be conducted side-by-side. The experimental calculator reports the change in profit between its results and the current property settings. We frequently observed participants using this tool.

- Below the Hawkes Bay interface we give a table of marginal profit in brown. This table gives the change in profit for change in water use. We did not observe many participants using this tool.

2.2. The Hawkes Bay Platform

In Hawkes Bay, each simulation represents one year with two seasons: period one is July to December, and period two is January to June. In each year participants decide on land use and their water use in each period.

In all scenarios farms receive some water directly from rainfall. In the introductory scenarios, rainfall was deterministic. In the later scenarios rainfall was stochastic. Participants' water take for irrigation is added to the rainfall to determine total water applied to their property. Some participants were initially confused by the difference between irrigation and total water.

Scenarios with stochastic rainfall ran as follows:

1. The scenario begins, all participants are informed of the details
2. Participants explore their profit functions
3. Participants negotiate and enter into bilateral trades, which are reported to the simulation manager and entered into the computer
4. Trading is completed
5. Rainfall is determined according to a dice roll
6. Participants finalize their land and water use decisions (no trading)
7. The scenario concludes

We typically think of stages 1-4 occurring at the very beginning of a year with stages 5 and 6 occurring during a year. The platform is able to lock some farmer decisions in place so they cannot be changed. For example, we can stop participants changing land use before the start of stage 5. We did not lock farmer decisions in all scenarios with stochastic weather as it appeared to have minimal impact and was costly in terms of participant time. We also ran some scenarios in which trading was allowed after determination of rainfall, to simulate the ability to make short-term trades in response to weather.

2.3. Properties and Profit Schedules

There are ten participants in the Hawkes Bay simulations: nine farms and the district council. A brief description of the design, intentions and expected behaviour for each participant is detailed below, along with their profit schedules.

Dairy farm 1:

A well functioning dairy farm. Recently established and hence has few water permits but very effective farming practices. Expected to buy allowances in both periods

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	1700	1900	2350	2800
1	1950	2150	2600	3050
2	2500	2700	3150	3600
3	3100	3300	3750	4200

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	650	700	950	1200
1	700	750	1000	1250
2	1050	1100	1350	1600
3	1400	1450	1700	1950

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1000	-1200
Sheep/Bee	1,800	0	-300
Forestry	2,600	1,100	0

Dairy farm 2:

A regular dairy farm. Somewhat more dependent on period 2 water than period 1, perhaps due to later lactation because of animal breed. Expected to sell period 1 allowances and buy period 2 allowances.

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	1600	1800	2250	2700
1	2400	2600	3050	3500
2	2700	2900	3350	3800
3	3000	3200	3650	4100

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	650	700	950	1200
1	1050	1100	1350	1600
2	1250	1300	1550	1800
3	1400	1450	1700	1950

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1000	-1200
Sheep/Bee	1,800	0	-300
Forestry	2,600	1,100	0

Dairy farm 3:

An older dairy farm. Has been in the catchment for a long time and hence has higher water allocation and less effective farming practices. Expected to sell allowances in both periods and may convert to sheep/beef farming.

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	1400	2100	2300	2500
1	2200	2900	3100	3300
2	2500	3200	3400	3600
3	2800	3500	3700	3900

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun			
	0	1	2	3
0	1000	1300	1400	1500
1	1450	1750	1850	1950
2	1600	1900	2000	2100
3	1750	2050	2150	2250

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1200	-1200
Sheep/Bee	1,800	0	-300
Forestry	2,600	1,100	0

Sheep/Beef farm 1:

A well functioning sheep/beef farm on excellent land. Newly established / converted. Looking to intensify. Expected to buy allowances in both periods and convert to dairy farming.

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	1600	2050	2500	2700
1	2200	2650	3100	3300
2	2800	3250	3700	3900
3	3000	3450	3900	4100

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	550	800	1050	1100
1	900	1150	1400	1450
2	1250	1500	1750	1800
3	1300	1550	1800	1850

Forestry

Profit	350	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1000	-1200
Sheep/Bee	1,800	0	-500
Forestry	2,600	900	0

Sheep/Beef farm 2:

An older sheep/beef farm on poor land. High water allocation for historical reasons. Most likely inherited. Expected to sell allowances and convert to forestry.

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	850	1350	1800	2250
1	1350	1850	2300	2750
2	1800	2300	2750	3200
3	2250	2750	3200	3650

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	600	800	1000	1150
1	850	1050	1250	1400
2	1100	1300	1500	1650
3	1350	1550	1750	1900

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1000	-12000
Sheep/Bee	1,900	0	-300
Forestry	2,600	900	0

Arable farm 1:

An Arable farm. Somewhat more dependent on period 1 water than period 2, perhaps due to their choice of crops. Expected to buy period 1 allowances and sell period 2.

Arable Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	500	700	850	900
1	1750	1950	2150	2250
2	2650	2850	3000	3100
3	3400	3600	3800	3900

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	650	750	900	1150
1	900	1000	1150	1400
2	1150	1250	1400	1650
3	1400	1500	1650	1900

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Arable	Sheep/Be	Forestry
Arable	0	-100	-300
Sheep/Bee	200	0	-200
Forestry	1,100	900	0

Arable farm 2:

An Arable farm. Somewhat more dependent on period 1 water than period 2, perhaps due to their choice of crops. Expected to buy period 1 allowances and sell period 2.

Arable Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	800	1000	1200	1200
1	1850	2000	2150	2250
2	2550	2700	2850	2950
3	3250	3400	3550	3650

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	650	750	850	1150
1	900	1000	1100	1400
2	1150	1250	1350	1650
3	1400	1500	1600	1900

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Arable	Sheep/Be	Forestry
Arable	0	-100	-300
Sheep/Bee	200	0	-200
Forestry	1,100	900	0

Viticulture:

A vineyard. Well established and well functioning, with irrigation used to cover dry spells. Expected to sell allowances of both periods in wet years but too risky to sell in dry years or when weather is unknown.

Viticulture Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	2150	3250	3350	3400
1	3250	6250	6450	6500
2	3350	6450	6550	6575
3	3400	6500	6575	6600

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	650	900	1100	1200
1	900	1150	1350	1450
2	1150	1400	1600	1700
3	1400	1650	1850	1950

Forestry

Profit	150	Only rainfall needed

Conversion Costs

From: \ To:	Viticultur	Sheep/Be	Forestry
Viticulture	0	-1400	-1800
Sheep/Bee	5,100	0	-200
Forestry	6,000	900	0

Forestry:

A forested property having just completed its harvest. The property owner / manager needs to decide this year whether to replant or convert into agriculture. Expected to buy allowances of both periods. Will convert to sheep/beef or dairy farming depending on number of successful allowance purchases.

Dairy Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	1700	1900	2600	2800
1	2000	2200	2900	3100
2	2800	3000	3700	3900
3	3100	3300	4000	4200

Sheep/Beef Profitability

Water: Jul-Dec	Water: Jan-Jun 0	1	2	3
0	700	1000	1100	1200
1	1150	1450	1550	1650
2	1300	1600	1700	1800
3	1450	1750	1850	1950

Forestry

Profit	250	Only rainfall needed

Conversion Costs

From: \ To:	Dairy	Sheep/Be	Forestry
Dairy	0	-1000	-1200
Sheep/Bee	1,800	0	-300
Forestry	2,600	1,100	0

District council:

The district council has a number of options regarding the water supply. They start with sufficient allowances to supply the town in a dry year. Their investment options are competitively priced and can be financed by selling allowances. If they are short on allowances (they sell too many) their only alternative is to truck water in at very high cost. Expected to invest and sell allowances in both periods.

Investment Options					
Option	Required Water		Costs		
	Jul-Dec	Jan-Jun	Operating	Investment	Total
None	8	8	600	0	600
Reduce Pressure	7	7	550	300	850
Replace Leaky Pipes	7	7	500	1450	1950
Increase Water Storage	7	7	600	400	1000
Implement Metering	6	6	800	500	1300

2.4. The Upper Waikato Platform

In the Upper Waikato, each simulation round represents one year. In each year participants decide on land use and land-use intensity.

Participant's land-use intensity is limited by their allowance holdings. In order to operate at a given intensity, participants must hold sufficient water, phosphorus and nitrogen allowances (where P and N are included in the scenario) for that intensity. It follows that a common situation for many participants is deciding which allowances to focus on (for example: either buy more phosphorus allowances – and use all their water allowances, or sell excess water allowances – and use all their phosphorus allowances).

Scenarios typically run as follows:

1. The scenario begins, all participants are informed of the details
2. Participants explore their profit functions
3. Participants negotiate and enter into bilateral trades, which are reported to the simulation manager and entered into the computer
4. Trading is completed
5. Participants finalize their land and water use decisions (no trading)
6. The scenario concludes

Properties are divided into two sub-catchments. Allowances from the up-river catchment can be traded down stream freely, but there are restrictions on the transfer of allowances from the down-river catchment to the up-river catchment.

2.5. Properties and Profit Schedules

There are ten participants in the Upper Waikato simulations: seven farms, a paper mill, the district council, and a hydro operator. A brief description of the design, intentions and expected behaviour for each participant are detailed below, along with their profit schedules. Note that we revised the profit schedules for the third session. Where we give two sets of profit schedules below, the first table gives the profit schedules for sessions 1 and 2, and the second table gives the profit schedules for session 3. Cells shaded dark green demonstrate how the interface indicates participants' current allowance holdings on their profit tables.

Dairy farm 1 – best practice:

Recently established dairy farm in the lower catchment. Currently operating at best practice due to regulation with the capacity to intensify further. Expected to buy allowances.

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.1	80	4100
5	2	1.0	70	4000
4	2	0.9	60	3800
3	1	0.8	50	3500
2	1	0.7	35	3100
1	0	0.6	20	2500

Arable

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.0	45	1800
5	3	0.9	40	1700
4	2	0.8	35	1600
3	2	0.7	35	1400
2	1	0.6	30	1100
1	1	0.4	20	600

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Forestry
Dairy B.P.	0	-500	-1000
Arable	2,200	0	-200
Forestry	2,400	2,100	0

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.6	60	4300
5	2	1.4	60	4200
4	2	1.3	60	4100
3	1	1.1	40	3600
2	1	1.0	40	3000
1	0	0.9	40	2200

Arable

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.0	40	2500
5	2	0.8	40	2300
4	2	0.8	30	2200
3	2	0.7	30	2000
2	1	0.5	30	1600
1	0	0.3	20	700

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Forestry
Dairy B.P.	0	-500	-1000
Arable	1,000	0	-200
Forestry	2,000	1,200	0

Dairy farm 2 – standard practice:

An older, longer established dairy farm in the upper catchment. While regulation has been introduced requiring the adoption of best practice the farm has been given ten years to make the required changes. Expected to sell allowances and convert to best practice under phosphorus regulation.

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.3	80	3900
5	3	1.2	70	3800
4	2	1.0	60	3700
3	2	0.9	50	3400
2	1	0.8	35	3000
1	1	0.7	20	2400

Dairy Standard Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	2.0	95	4200
5	3	1.8	85	4100
4	2	1.6	75	3900
3	1	1.4	65	3600
2	1	1.2	50	3000
1	0	1.0	35	2200

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Dairy Std	Forestry
Dairy B.P.	0	200	-1000
Dairy Std	500	0	-1000
Forestry	2,400	2,100	0

Dairy Best Practice Profitability

System	Water	Phosphori	Nitrogen	Profit
6	3	1.6	60	4150
5	2	1.4	60	4000
4	2	1.3	60	3900
3	1	1.1	40	3600
2	1	1.0	30	3000
1	0	0.9	20	2200

Dairy Standard Profitability

System	Water	Phosphori	Nitrogen	Profit
6	3	2.0	90	4200
5	3	1.8	90	4100
4	2	1.6	90	3800
3	1	1.4	60	3400
2	1	1.2	60	3000
1	0	1.0	30	2200

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Dairy Std	Forestry
Dairy B.P.	0	200	-1000
Dairy Std	500	0	-1000
Forestry	2,400	2,100	0

Dairy farm 3 – standard practice:

As per Dairy farm 2, but located in the lower catchment.

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.3	80	4000
5	2	1.2	70	3950
4	2	1.1	60	3800
3	2	1.0	50	3500
2	1	0.9	35	3100
1	0	0.8	20	2400

Dairy Standard Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	2	2.1	95	4200
5	2	2.0	85	4100
4	2	1.8	75	3900
3	1	1.6	65	3600
2	1	1.3	50	3200
1	0	1.0	35	2400

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Dairy Std	Forestry
Dairy B.P.	0	200	-1000
Dairy Std	500	0	-1000
Forestry	2,400	2,100	0

Dairy Best Practice Profitability

System	Water	Phosphori	Nitrogen	Profit
6	3	1.5	60	4100
5	2	1.3	60	3950
4	2	1.1	60	3800
3	2	1.0	50	3500
2	1	0.9	30	3100
1	0	0.8	20	2400

Dairy Standard Profitability

System	Water	Phosphori	Nitrogen	Profit
6	2	2.1	90	4100
5	2	1.9	90	3900
4	2	1.8	90	3800
3	1	1.6	60	3400
2	1	1.3	60	3000
1	0	1.0	30	2300

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Dairy Std	Forestry
Dairy B.P.	0	200	-1000
Dairy Std	500	0	-1000
Forestry	2,400	2,100	0

Sheep/Beef farm:

A well functioning sheep/beef farm in the upper catchment. The farm has recently changed owners and is looking to intensify. Expected to buy allowances and convert to a more intensive land use.

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.1	80	3950
5	2	1.0	70	3900
4	2	0.9	60	3750
3	2	0.8	50	3350
2	1	0.7	35	2800
1	0	0.6	20	2150

Arable Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.0	45	2000
5	3	0.8	40	1950
4	2	0.7	35	1900
3	2	0.6	35	1750
2	2	0.5	30	1300
1	1	0.4	20	800

Sheep/Beef Profitability

Water	Phosphori	Nitrogen	Profit
0	0.5	35	1200

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Sheep/Be
Dairy B.P.	0	-500	-600
Arable	2,100	0	-100
Sheep/Bee	2,200	200	0

Dairy Best Practice Profitability

System	Water	Phosphor	Nitrogen	Profit
6	3	1.5	60	3950
5	2	1.3	60	3900
4	2	0.9	60	3750
3	2	0.8	50	3350
2	1	0.7	30	2800
1	0	0.6	20	2150

Arable Profitability

System	Water	Phosphor	Nitrogen	Profit
6	3	1.0	50	2000
5	3	0.8	40	1950
4	2	0.7	40	1900
3	2	0.6	30	1750
2	2	0.5	30	1300
1	1	0.4	20	800

Sheep/Beef Profitability

Water	Phosphor	Nitrogen	Profit
0	0.5	20	1200

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Sheep/Be
Dairy B.P.	0	-500	-600
Arable	1,000	0	-100
Sheep/Bee	1,600	200	0

Arable farm:

A productive arable farm in the lower catchment. A recent nutrient management planning audit has identified ways for the farm to be more resource efficient with minimal impact on profitability. Expected to sell allowances.

Dairy Best Practice Profitability

Intensity	Water	Phosphor	Nitrogen	Profit
6	3	1.0	80	4000
5	2	0.9	70	3900
4	2	0.8	60	3750
3	2	0.7	50	3500
2	1	0.6	35	3100
1	0	0.6	20	2400

Arable Profitability

Intensity	Water	Phosphor	Nitrogen	Profit
6	3	1.0	45	1950
5	3	0.8	40	1900
4	2	0.7	35	1800
3	2	0.6	35	1600
2	1	0.5	30	1300
1	1	0.3	20	800

Forestry Profitability

Water	Phosphor	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Forestry
Dairy B.P.	0	-500	-1000
Arable	2,200	0	-200
Forestry	2,400	2,100	0

Dairy Best Practice Profitability

System	Water	Phosphor	Nitrogen	Profit
6	3	1.5	60	4000
5	2	1.3	60	3900
4	2	0.8	60	3750
3	2	0.7	50	3500
2	1	0.6	30	3100
1	0	0.6	20	2400

Arable Profitability

System	Water	Phosphor	Nitrogen	Profit
6	3	1.1	50	2500
5	3	0.8	40	2350
4	2	0.7	30	2100
3	2	0.6	30	2000
2	1	0.5	20	1300
1	1	0.3	20	800

Forestry Profitability

Water	Phosphor	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Arable	Forestry
Dairy B.P.	0	-500	-1000
Arable	1,200	0	-200
Forestry	2,400	2,100	0

Forestry 1:

A forestry area in the upper catchment. The land had been recently harvested and the owner now needs to decide whether to remain in forestry or convert to a different land use. Expected to buy allowances and convert to a more intensive land use.

Dairy Best Practice Profitability

Intensity	Water	Phosphor	Nitrogen	Profit
6	3	1.3	80	3900
5	2	1.2	70	3850
4	2	1.1	60	3750
3	1	1.0	50	3550
2	1	0.9	35	3000
1	0	0.8	20	2400

Sheep/Beef Profitability

Intensity	Water	Phosphor	Nitrogen	Profit
6	1	0.9	55	1600
5	1	0.8	50	1700
4	1	0.7	40	1650
3	0	0.6	35	1550
2	0	0.5	30	1400
1	0	0.4	25	1150

Forestry Profitability

Water	Phosphor	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Sheep/B	Forestry
Dairy B.P.	0	-600	-1000
Sheep/Bee	2,200	0	-100
Forestry	2,400	600	0

Dairy Best Practice Profitability

System	Water	Phosphori	Nitrogen	Profit
6	3	1.5	60	3900
5	2	1.3	60	3850
4	2	1.1	50	3750
3	1	1.0	40	3550
2	1	0.9	30	3000
1	0	0.8	20	2400

Sheep/Beef Profitability

System	Water	Phosphori	Nitrogen	Profit
6	1	0.9	40	1800
5	1	0.8	40	1750
4	1	0.7	30	1650
3	0	0.6	30	1550
2	0	0.5	20	1400
1	0	0.4	10	1150

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Sheep/Be	Forestry
Dairy B.P.	0	-600	-1000
Sheep/Bee	1,600	0	-100
Forestry	2,000	600	0

Forestry 2:

As per forestry 1. But with different profit schedules.

Dairy Best Practice Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	3	1.1	80	4000
5	2	1.0	70	3900
4	2	0.9	60	3700
3	1	0.8	50	3400
2	1	0.8	35	3100
1	1	0.7	20	2500

Sheep/Beef Profitability

Intensity	Water	Phosphori	Nitrogen	Profit
6	1	0.8	55	1850
5	1	0.7	50	1800
4	1	0.6	40	1700
3	1	0.5	35	1550
2	0	0.4	30	1400
1	0	0.3	25	1200

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Sheep/B	Forestry
Dairy B.P.	0	-600	-1000
Sheep/Bee	2,200	0	-100
Forestry	2,400	600	0

Dairy Best Practice Profitability

System	Water	Phosphori	Nitrogen	Profit
6	3	1.5	60	4000
5	2	1.3	60	3900
4	2	0.9	60	3700
3	1	0.8	50	3400
2	1	0.8	30	3100
1	1	0.7	20	2500

Sheep/Beef Profitability

System	Water	Phosphori	Nitrogen	Profit
6	1	0.8	40	1850
5	1	0.7	40	1800
4	1	0.6	40	1700
3	1	0.5	30	1550
2	0	0.4	20	1400
1	0	0.3	10	1100

Forestry Profitability

Water	Phosphori	Nitrogen	Profit
0	0.2	5	150

Conversion Costs

From: \ To:	Dairy B.P.	Sheep/Be	Forestry
Dairy B.P.	0	-600	-1000
Sheep/Bee	1,600	0	-100
Forestry	2,000	600	0

Paper Mill:

A paper mill operating in the lower catchment. They are able to reduce output or invest in technology to reduce water take and/or nutrient loss. Expected to invested and sell allowances.

Investment Options

Option	Output	Water Take	Phosphorus Emissions	Nitrogen Emissions	Profit
Status quo	120	5	2.5	30	3500
Reduce output 1	100	4	2.0	25	3000
Reduce output 2	80	3	1.6	22	2500
Install clean tech 1	120	4	2.5	30	3250
Install clean tech 2	120	5	1.7	25	2625
Install clean tech 1&2	120	4	1.7	25	2400

Investment Options					
Option	Output	Water Take	Phosphoru Emissions	Nitrogen Emissions	Profit
Status quo	120	5	2.5	90	3500
Reduce output 1	100	4	2.0	70	3000
Reduce output 2	80	3	1.6	60	2500
Install clean tech 1	120	4	2.5	70	3250
Install clean tech 2	120	5	1.7	60	2625
Install clean tech 1&2	120	4	1.7	50	2400

District Council:

The district council operates in the lower catchment. There are responsible both for water supply and sewage disposal. Expected to invest and sell allowances.

Investment Options				
Option	Water Take	Phosphorus Emissions	Nitrogen Emissions	Operating Cost
Status Quo	6	1.0	6	2000
Fix leaky pipes	5	1.0	6	3000
Water Restrictions	5	1.0	6	2200
Treat to remove P	6	0.7	5	2500
Land Disposal	6	0.5	1	3500

Investment Options				
Option	Water Take	Phosphoru Emissions	Nitrogen Emissions	Operating Cost
Status Quo	6	1.0	10	2000
Fix leaky pipes	5	1.0	10	3000
Water Restrictions	5	1.0	10	2200
Treat to remove P	6	0.7	10	2500
Land Disposal	6	0.5	0	3500

Hydro Operator:

The hydro operator controls two dams: the first between the upper and lower catchments and the second at the bottom of the lower catchment. They hold some water allowances and are expected to try to sell these allowances. Any water not taken / used by the other participants goes through the hydro operator's dams regardless of the hydro operator's allowance holdings.

Profit from Upper Catchment Flow				Profit from Lower Catchment Flow				Notes
Flow out	Income	Flow out	Income	Flow out	Income	Flow out	Income	Profit demands on flow out of catchment.
120	2,250	113	1,900	204	3,500	190	2,800	Flow out = flow in - water take for irrigation.
119	2,200	112	1,850	202	3,400	188	2,700	
118	2,150	111	1,800	200	3,300	186	2,600	Flow into Upper catchment = 120
117	2,100	110	1,750	198	3,200	184	2,500	
116	2,050	109	1,700	196	3,100	182	2,400	Flow into Lower catchment =
115	2,000	108	1,650	194	3,000	180	2,300	flow out of upper catchment
114	1,950	107	1,600	192	2,900	178	2,200	+ tributary flow of 90

2.6. Trading

Bilateral trading in the simulations requires participants who have agreed on a trade to complete a trading form (examples of which are given below). Paper copies of these forms are printed prior to the session and made available to participants.

Completed forms are handed to the simulation manager who inputs them into the master control file. Once the trades have been entered and the Hub file has been saved, participants click the "Update" button on their interface and it displays their new allowance holdings.

Hawkes Bay trading forms:

Buyer	Seller	Oct-Dec Allowances		Jan-Mar Allowances	
		Number Traded	Total Price	Number Traded	Total Price

Signed:

_______________________________ _______________________________

Buyer Seller

Jul-Dec Allowances		Jan-Jun Allowances		Storage Allowances		Duration
Number Traded	Total Price	Number Traded	Total Price	Number Traded	Total Price	

Buyer: ___________________________ Seller: ___________________________

Upper Waikato trading forms:

Buyer	Seller	Water Allowances		Phosphorus Allowances	
		Number Traded	Total Price	Number Traded	Total Price

Signed:

_______________________ _______________________

Buyer Seller

Water Allowances		Phosph. Allowances		Nitrogen Allowances		Duration
Number Traded	Total Price	Number Traded	Total Price	Number Traded	Total Price	

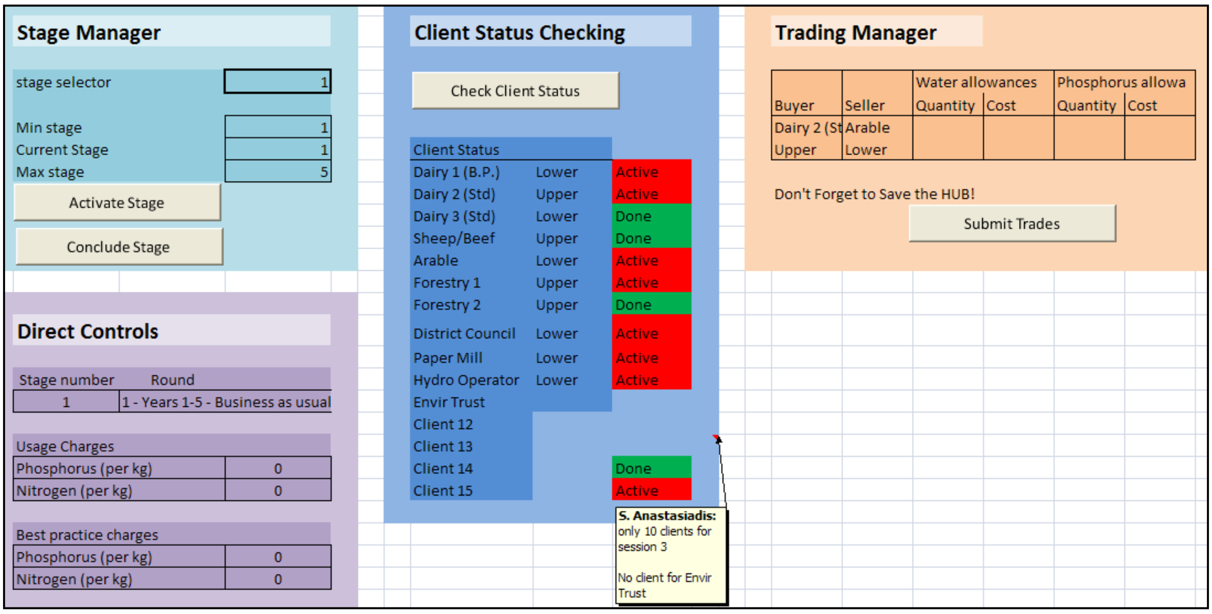
Buyer: ______________________________ Seller: ______________________________

2.7. Master Control and Hub

The master control file contains the simulation controls, trading mechanics, and data entry. An example of the simulation manager's interface is given below.

The light blue section is used to start, select and conclude simulation rounds. The dark blue section indicates participants current status: either "Active" (red) – still making farm management decisions; or "Done" (green) – finished making decisions and waiting for the round to end. Trades are entered into the orange section. Clicking the submit button saves the trade to another part of the file. The purple section contains controls that can be set to create different regulatory environments.

Master control interface:



The Hub file is used to facilitate data transfer between the master control and client files. During the development of the simulation platform the intention was to run some sessions remotely. In anticipation of this, we designed the platform to use the Hub file for data transfer. As the Hub file is much smaller than the master control file, this would have enabled faster transfer of data via the internet.

3. Scenarios

In this section we describe scenarios that were run using the simulation platform. Each scenario can take 20 to 30 minutes to run, depending on the complexity of the scenario and the engagement of participants.

3.1. Hawkes Bay – session 1

The first Hawkes Bay session was intended to introduce participants to the simulation platform, give them a chance to trade and experience uncertainty. River condition in each period was reported after each scenario according to the following table.

Total Water take	***River condition***
< 15	Excellent
15-18	Good
19-22	Fair
> 22	Poor

Scenario 1 is primarily for participants to familiarize themselves with the user interface. There is no trading, uncertainty or regulation. Rainfall is known to be 1 in each period. Each participant chooses their land and water use, given their allowance holdings.

Scenario 1 is presented as reflecting the status quo, or current situation, and we note the river condition is lower than desired.

Scenario 2 addresses the river condition by reducing some participants' resource consents. Other than a change in participant's permitted water takes, this scenario is identical to scenario 1.

Scenario 2 is described as the council or regulator intervening to improve the river condition. We note that this improvement reduces total profits in the catchment.

Scenario 3 is the first scenario with trading. Participants start with the same allowance holdings as in scenario 2 but are free to trade allowances amongst each other. Rainfall is known to be 1 in each period.

Scenario 3 is described as the council recognising that the reduced allocations have caused hardship and permitting the transfer of water permits to reduce this hardship. We note that trading results in increased profit to the catchment with no deterioration in river condition.

Scenario 4 introduces weather uncertainty. The general weather pattern is known (La Niña – "normal to wet") but the exact rainfall in each period is determined by a dice roll according to the following table. There is no access to trading in this scenario.

La Niña – wet		
Dice	*Weather*	*Rain*
1	Dry	0
2	Normal	1
3	Normal	1
4	Normal	1
5	Wet	2
6	Wet	2

Scenario 4 is described as a more realistic alternative to scenario 2, and we compare it to scenarios 5, 6 and 7.

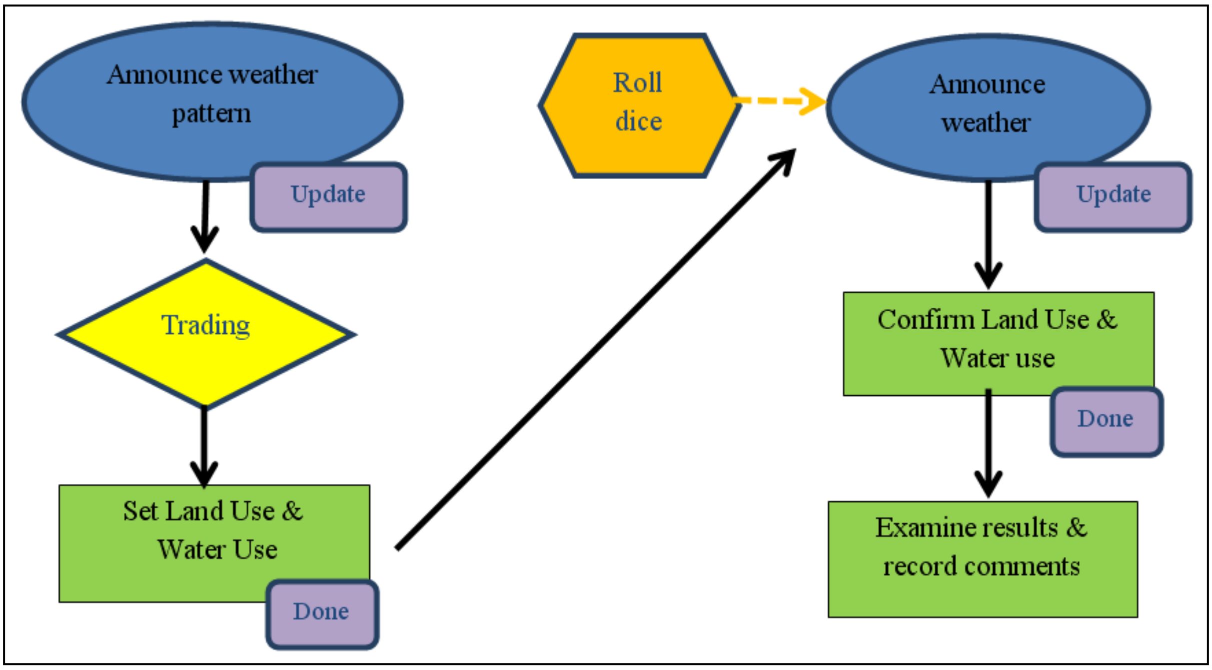
Scenario 5 is identical to scenario 4 but allowance trading is permitted prior to the dice being rolled for weather. This enables participants to hold allowances as a way of managing the risk that there may be very little (zero) rain.

Scenario 6 is identical to scenario 5 but allowance trading of period 2 allowances is also permitted *after* the dice has been rolled for weather. This enables participants to make short-term trades in response to weather.

Scenario 7 is identical to scenario 5 but with El Niño (normal to dry) weather. Participants indicated that trading prior to knowing the weather was more realistic than trading in response to knowing the weather.

El Niño – dry		
Dice	*Weather*	*Rain*
1	Dry	0
2	Dry	0
3	Dry	0
4	Normal	1
5	Normal	1
6	Wet	2

The following diagram gives the decision sequence for scenarios 5 and 7:



3.2. Hawkes Bay – session 2

The second Hawkes Bay session introduced a new entity: the River Trust. The trust receives revenues according to the scenario and can invest these revenues to improve the condition of the river. River condition is determined according to the table used for session 1. Rainfall for all scenarios is stochastic and is determined according to the El Niño weather pattern.

Scenario 1 introduces water use charges of $50 per unit of water used. Unused allowances do not occur a charge. The size of the charge ($50) was considered small compared to the expected value of allowances ($150 – 250). Revenue from the charges is used by the River Trust to improve the condition of the river.

The water use charge is expected to have minimal impact on participants' trading and water use decisions.

Scenario 2 is identical to scenario 1 but the charge is increased to $150. We note that as the charge is large (in comparison to the value of allowances) some participants may be better off holding unused allowances rather than paying the charge to use their allowances.

Scenario 3 is identical to scenario 1 but the charge is based on water allocation rather than use. So participants are charged based on allowance holdings regardless of whether they exercise their rights to extract water from the river or not.

Scenario 4 is identical to scenario 3 but the charge is increased to $150. Participants who wanted to hold fewer allowances (to avoid the charge) but were unable to find a buyer for their allowances could retire their allowances by giving them to the River Trust.

Scenario 5 replaces the charges with a uniform price auction. Every participant loses 1 allowance for each period and these are auctioned off by the trust according to a uniform price auction. All revenue from the sale of allowances goes to the trust.

Scenario 6 is a repeat of scenario 5. Participants indicated that they found the auction confusing and wanted to try again.

Scenario 7 explores market power. One participant (arable farm 1) is initially allocated about 60 percent of the allowances. There are no charges or auction in this scenario. The river trust earns no revenue and does not work to improve the river condition.

3.3. Hawkes Bay – session 3

The third Hawkes Bay session consisted of five sequential scenarios, each of which represented approximately five years. Participants can enter into long term trades that last for multiple scenarios. Changes in land use carry over between scenarios. All scenarios have uncertain El Niño weather.

We also introduced an investment option for water storage that holds 32 units of water each year. Stored water can be used, in conjunction with run-of-river water and rainfall, to irrigate land in either period. Water storage can be built in scenario 2 (or later) if there is sufficient demand for storage water (at least 25 of the 32 units pre-purchased for $250 per unit per year). Any units of stored water not purchased at the construction of the storage are retained by the council. The total cost of the storage is $8,000 per year.

To enable participants to make use of stored water, each property is expanded to include a second block of dry (unirrigated) land with the same land use as participants' first block of land. Participants may extend their irrigation to include the dry block of land. If they do so then both blocks of land have the same irrigation (this simplifies the decision making so participants do not have to manage two separate blocks of land – the decision for the dry block is: irrigate or dry land).

Scenario 1 represents years 1 to 5. Participants have initial allocations as per scenario 1 in session 1 (so the river is over allocated) and are able to trade allowances. We think of this scenario as status quo or business as usual.

Scenario 2 represents years 6 to 10. In response to the poor river condition the council has reduced participants' allocations, presented as not renewing all resource consents (as per scenario 2 in session 1).

To reduce the hardship this might cause, investment in a water storage scheme is available. Participants are given opportunity to purchase allowances for stored water, with those participants with fewer run-of-river allowances in scenario 2 offered a greater share of the allowances for stored water.

Once the water storage scheme is built (or delayed until the next scenario) participants may trade allowances and make land use decisions.

Scenario 3 represents years 11 to 15. It is similar to scenario 2: having the same initial allocations, including stored water if storage was built, or opportunity to invest in stored water if it was not build. However, we introduce changes in commodity prices causing the return to different land uses to change as follows:

Land use	Change from scenario 2
Dairy	-10%
Sheep/Beef	+30%
Arable	-20%
Forestry	+15%
Viticulture	-20%

Scenario 4 represents years 16 to 20. It is identical to scenario 3 but with different changes in the return to land uses as follows:

Land use	Change from scenario 2
Dairy	+10%
Sheep/Beef	+10%
Arable	+10%
Forestry	+15%
Viticulture	+10%

Scenario 5 represents year 21 to 25. It is identical to scenarios 3 and 4 but the return to changes in land uses as per scenario 2 (so no changes in commodity prices compared to scenarios 1 and 2).

3.4. Upper Waikato – session 1

The first Upper Waikato session was intended to introduce participants to the simulation platform, give them a chance to trade and experience the (potential) complexity of jointly managing two kinds of allowances: water and nutrient discharges.

We differentiate between upper and lower river sub-catchments. River condition was reported after each scenario according to the following tables. Upstream river condition depends only on the behaviour of upstream participants, while downstream river condition depends on the behaviour of all participants.

Waikato River condition (Downstream)

Total Water use	***Phosphorus P <7.5***	***7.5 – <9.0***	***9.0 - <11.0***	***>11***
< 27	Excellent	Good	Fair	Poor
27-32	Good	Good	Fair	Poor
> 32	Good	Fair	Poor	Poor

Waikato River condition (Upstream)

Total Water use	***Phosphorus P <2.2***	***2.2 – 4.0***	***>4.0 - 5.0***	***>5.0***
< 10	Excellent	Good	Fair	Poor
10-14	Good	Good	Fair	Poor
> 14	Good	Fair	Poor	Poor

To help facilitate trading, we provide a bulletin board where participants can post offers to buy and sell (this is typically a white board at the front of the room).

Scenario 1 is primarily for participants to familiarize themselves with the user interface. Participants only require allowances for water takes (nutrients are unregulated) and are unable to trade. Each participant chooses their land use and intensity given their allowances.

Scenario 1 is described as reflecting the status quo, or current situation, and we note the river condition is lower than desired. We also note that not all allowances for water take are used (there are sleeper permits).

Scenario 2 recognizes that there are unused allowances and permits trading in order to encourage more effective use of water. As per scenario 1, only water takes are regulated. We expect that the river condition will worsen as the sleeper permits are used.

Scenario 3 builds on scenario 2 and introduces protective measures on the upstream catchment. Water takes in the upstream catchment is limited to be at most 8 units. Trades are resolved on a first-come-first-served basis but will be refused if they would permit water takes of more than 8 in the upstream catchment.

Scenario 4 is the first scenario where nutrients (phosphorus) are regulated. All participants now have allowances for both water take (as per scenario 1) and phosphorus emissions. The total limit for the catchment is 8.5 units of phosphorus (about a 20% reduction from scenario 1). Trading of allowances is not permitted.

Scenario 5 extends scenario 4 to allow trading of phosphorus allowances but not water allowances. Phosphorus emissions in the upstream catchment are limited to be at most 3.5 units.

Trades are resolved on a first-come-first-served basis but will be refused if they would permit phosphorus emissions of more than 3.5 units in the upstream catchment.

Scenario 6 extends scenario 5 to allow trading of both water and phosphorus allowances. Participants are encouraged to consider trading bundles of allowances. The limits on water and phosphorus in the upstream catchment (from scenarios 3 and 5) apply.

Scenario 7 is identical to scenario 6 but removes the restriction on upstream trades. We compare scenarios 4 and 5, and scenarios 4, 6 and 7 to identify gains from trading allowances.

3.5. Upper Waikato – session 2

The second Upper Waikato session continues on from the first session to consider different initial allocations and charges. River condition is determined according to the tables used for session 1.

Scenario 1 is identical to scenario 6 from session 1. This serves as a quick introduction for any participants who did not attend the first session.

Scenario 2 is identical to scenario 1, but participants begin the scenario with different allowance allocations. We use an average allocation for both water and phosphorus, where all agricultural properties receive (approximately) the same number of allowances (non-agricultural properties lose a small number of allowances, these are distributed between agricultural properties).

Scenario 3 returns to the allocations in scenario 1 but introduces charges for each unit of water or phosphorus used. The charges are set to be 5% of the value of allowances in scenario 2 (so the charge is small – $4 per unit of water and $10 per unit of phosphorus).

We describe the revenue raised from these charges as being used to address equity issues with the initial allocation, going to a River Trust to improve the river condition, or as general funds for water management.

Scenario 4 is explained as the first year of three sequential rounds where participants are able to make trades that will last more than year. Participants are warned at the start of this scenario that they will be unable to change land use in scenarios 5 and 6, and that any conversion costs will have to be paid in all three rounds.

During this round one participant is chosen by the simulation manager to play the role of a speculator. They are secretly informed that allowances, of both types, will be highly valuable in scenario 5, and are encouraged to buy up allowances in long term trades now. We prefer to choose a forestry property for this role, as they could use intensification to justify purchasing large quantities of allowances.

Scenario 5 is the second year of the three sequential rounds. In line with the speculator's expectations, commodity prices have increased the return to all land uses as follows:

Land use	Change from scenario 5
Dairy	+30%
Sheep/Beef	+40%
Arable	+20%
Forestry	+20%
Industry (ex. Hydro)	+20%

If the speculator was successful in making long term trades during scenario 4, they should have allowances to spare in scenario 5 and should be able to make significant profits from the sale of those allowances.

Scenario 6 is the third year of the three sequential rounds. Counter to the speculator's expectations, the increase in commodity prices was temporary. And prices have now declined beneath their starting values in scenario 4.

Land use	Change from scenario 5
Dairy	-20%
Sheep/Beef	-20%
Arable	-10%
Forestry	-10%
Industry (ex. Hydro)	-10%

If the speculator still has allowances from making long term trades during scenario 4 they will find that their allowances have lost much of their value. We discuss scenarios 4, 5 and 6 to highlight the risk to speculators of purchasing allowances for future sale.

3.6. Upper Waikato – session 3

The third Upper Waikato session consists of five sequential scenarios, each of which represents approximately five years. Participants can enter into long term trades that last for multiple scenarios. Changes in land use carry over between scenarios (as do the costs of land use change and acquisition or sale of allowances).

We introduce nitrogen as a further nutrient of concern in the river. Participants are therefore required to manage three types of allowances (water, phosphorus and nitrogen). River condition is reported after each scenario according to the following tables:

Waikato River condition (Downstream)

Total Water use	***Nutrients P <7.5 & N < 330***	***7.5 ≤ P <9.0 OR 330 ≤ N < 400***	***9.0 ≤ P < 11.0 OR 400 ≤ N < 500***	***P >11 OR N > 500***

< 27	Excellent	Good	Fair	Poor
27-32	Good	Good	Fair	Poor
> 32	Good	Fair	Poor	Poor

Waikato River condition (Upstream)

Total Water use	***Nutrients P <2.2 & N < 100***	***P =2.2 – 4.0 OR 100 < N ≤ 120***	***4.0 < P ≤ 5.0 OR 120 < N < 140***	***P > 5.0 OR N > 140***
< 10	Excellent	Good	Fair	Poor
10-14	Good	Good	Fair	Poor
> 14	Good	Fair	Poor	Poor

Scenario 1 represents years 1 to 5. Only water takes are regulated and trading is permitted. Participants are informed that the council is introducing nutrient regulation for both Nitrogen and Phosphorus and that this will be phased in over the next ten years (i.e. starting in Scenario 3) with initial allocations based on last year's land use.

We think of this scenario as status quo or business as usual. The warning that the council will introduce nutrient regulation based on past land use is expected to discourage participants intensifying land use.

Scenario 2 represents years 6 to 10. As an interim step before implementing a nutrient trading scheme, the council has defined best practice emissions for all properties and has introduced charges for nutrient emissions that exceed best practice.

The following table gives the best practice emission levels. The charge for emissions that exceed these levels is $5 per kg of nitrogen and $250 per kg of phosphorus.

	Nitrogen limits (kg)	*Phosphorus limits (kg)*
Dairy	60	1.6
Arable	50	0.9
Dry Sheep/Beef	20	0.5
Irrigated Sheep/Beef	30	0.6
Forestry	10	0.2

Scenario 3 represents years 11 to 15. In this scenario, participants are given tradable N and P allowances. As per session 1 and 2, the upper catchment is protected by limits on water take and nutrient emissions. The limit for nitrogen emissions in the upper catchment is 120 units.

The charges for nutrient emissions are reduced and changed to apply to all discharges from all properties. The new charges are $2 per kg for nitrogen and $100 per kg for phosphorus.

Scenario 4 represents years 16 to 20. This scenario is identical to scenario 3. We include it to give participants another opportunity to trade in a situation where there are three different types of allowances.

Scenario 5 represents years 21 to 25. This scenario begins with an all-in uniform price auction for one nutrient. We auction the nutrient that appears to be more limiting in the catchment. Following the auction the remainder of this scenario is identical to scenarios 3 and 4.

An all-in uniform price auction works as follows: All allowances of the nutrient are available for auction (participants cannot opt-out). All participants submit bids for allowances. The bids are ranked and as many are possible are satisfied in descending order. The lowest satisfied bid determines the market clearing price.

All participants with more allowances after the auction than they had before pay the market clearing price for each allowance gained. All participants will fewer allowances after the auction than they had before, receive the market clearing price for each allowance gained. It follows that a participant who wins the exact number of allowances as they held before the auction pays nothing.

4. Future Potential

The simulation platform (including its scenarios, and the documents and language that support it) forms a valuable resource for future research and teaching. The simulations were enjoyed by participants and we encourage future users to build on these resources, rather than starting afresh.

Role-playing simulations using such a platform can be helpful to facilitate discussion. Both sides of an issue can be drawn in to focus their discussion on the results of the simulation and how the results might differ were the scenario to occur in real life. This can reduce hostility and foster partnership between participants by encouraging them to critique the simulation scenarios, rather than each other.

We would encourage the use of the simulation platform and associated materials as a research or teaching tool for farmers, regional and district council members, policy designers, consultants, and students of agricultural economics. At present we have developed scenarios that explore issues associated with allowance trading, trading zones, water charges, uncertainty, initial allocation, auctions, market power, short vs. long term trades, and price variability. Though we have developed this platform in the context of run-of-river irrigation, it would be straightforward to adapt to connected groundwater bores, natural or artificial lakes.

We recognise that the computer based nature of the simulation platform may reduce its usefulness as a research or teaching tool: Participants may be intimidated by the (perceived) skill requirements of operating the platform (though these are very low); Organizers may find the venue requirements (especially the need to network computers) limit their choice of venue; Participants and organizers who value face-to-face interaction may feel that the use of computers detracts from this. We are confident that the platform could be adapted to a board game format in order to overcome these limitations.

The simulations could be further enhanced by additional communication resources, such as short films explaining the issues and stakeholders' perspectives (for existing examples of these, see www.motu.org.nz/research/detail/rotorua_films).