

Is punishment always effective?  
Evidence from an experimental study

## Demographics

More statistics on the data from the qualification test are shown below.

Table 1. Age vs. Qualification			
	Qualified		Total
	No	Yes	
Age			
Under 18	2	0	2
18 - 24	180	72	252
25 - 34	1,081	462	1,543
35 - 44	710	324	1,034
45 - 54	297	174	471
55 - 64	178	76	254
65 - 74	48	32	80
75 - 84	2	2	4
85 or Older	3	1	4
Gender			
Female	1,040	590	1,630
Male	1,461	553	2,014
Education			
4-year Degree	1,434	596	2,030
Doctorate	29	21	50
High School Graduate	162	95	257
Less than High School	5	3	8
Professional Degree	508	200	708
Some College	363	228	591
Experience			
None	336	547	883
Less than 1 Year	323	142	465
1-3 Years	994	243	1,237
3-6 Years	573	115	668
More than 6 years	275	96	371
Employment			
Homemaker	119	71	190
Retired	64	40	104
Student	45	33	78
Unemployed	65	49	114
Working full-time	1,827	778	2,605
Working part-time	381	172	553
Income			
Under \$10,000	208	144	352
\$10,000-\$20,000	275	128	403
\$20,000-\$30,000	392	156	548
\$30,000-\$45,000	430	201	631
\$45,000-\$60,000	569	221	790
\$60,000-\$80,000	370	151	521
\$80,000-\$120,000	209	90	299
Over \$120,000	48	52	100

## Groundwater recharge

Researchers have shown that overextraction and exhaustion of groundwater can affect the recharge rate (Tsur & Zemel, 2004). In other words, complete groundwater depletion can lead to irreversible aquifer deformation and destruction, preventing storage of water. Figure 1 shows different patterns of behavior with respect to the key selected variables (scenarios S1 to S6). S1 is the baseline where orchards and pumping rate do not change, and the groundwater level remains constant.

S2, S3, and S4 show that orchards area increases and then decreases over time. S2 shows a slight increase in orchards, resulting in decline of groundwater. As orchards reaches the initial value, groundwater stops declining and stays at a new equilibrium. The pumping rate falls below the desired level because of the effect of lower groundwater level on outflow. S3 exhibits a higher increase in orchards in the early periods. As a result, groundwater level decreases, leading to a lower pumping rate. However, as orchards area declines and remains low for several periods, groundwater gradually grows, reaching to its initial value. S4 shows that a much higher increase in orchards leads to a huge decline in groundwater, resulting in extremely lower water inflow. Because the aquifer is exceedingly depleted, the inflow remains low even after orchards area declines.

S5 and S6 show that orchards area declines and then increases over time. S5 demonstrates a huge decrease in orchards area resulting in a constant increase in groundwater level. Groundwater growth becomes slower as orchards area returns to the equilibrium. S6 shows that although groundwater increases for several periods due to a decrease in orchards, it declines as orchards grow and remain above the equilibrium.

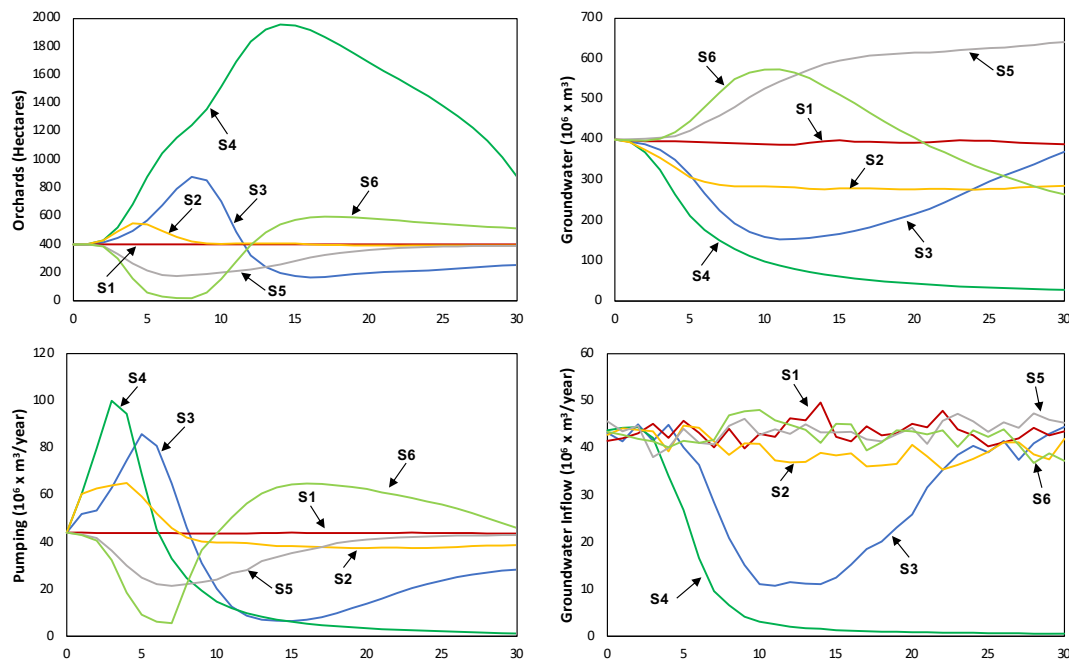


Figure 1. Different patterns of behavior regarding the key selected variables; orchards, groundwater, pumping rate, and groundwater inflow.

## Groundwater co-flow

We used a co-flow structure to capture the individual effect of pumping rates on groundwater as well as their separate impacts on production.

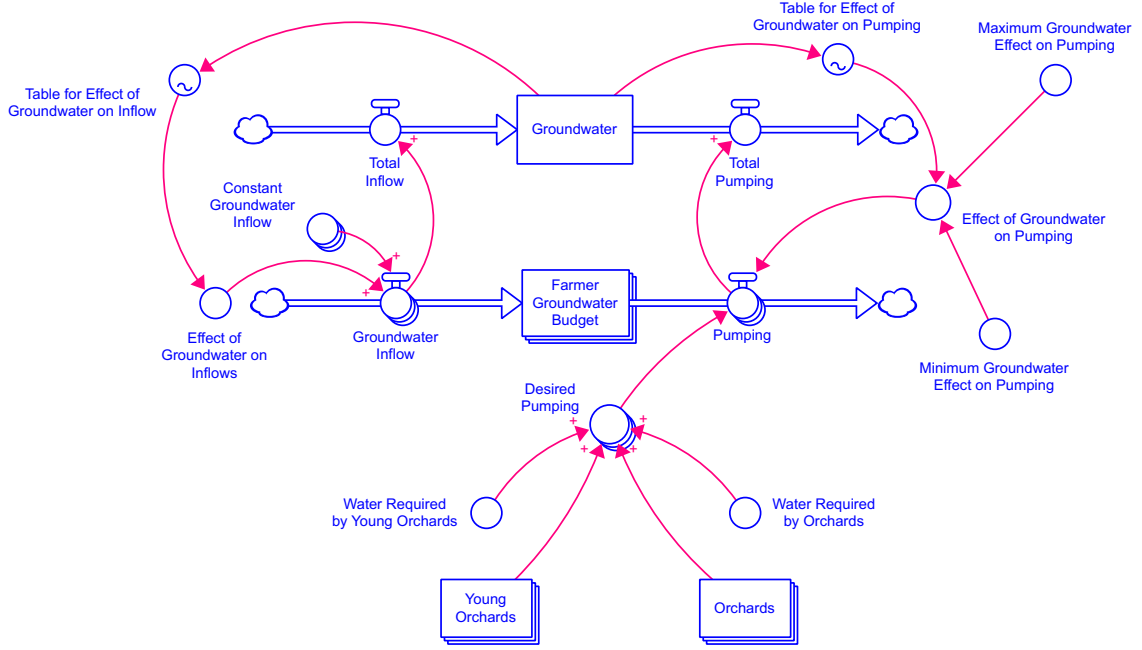


Figure 2. Implementation of the co-flow structure in the groundwater sector

## Additional information on orchards sector

We explicitly captured the third-order delay for young orchards using three separate stocks (Figure 3). We used first-order delays governing the outflows ( $Y_{12}$ ,  $Y_{23}$ , and  $GR_O$ ) to calculate the changes in young orchards ( $Y_1$ ,  $Y_2$ , and  $Y_3$ ):

$$Y_1 = GR_Y - Y_{12} \quad (1)$$

$$Y_2 = Y_{12} - Y_{23} \quad (2)$$

$$Y_3 = Y_{23} - GR_O \quad (3)$$

We captured the outflows as the stocks divided by the third of the growth delay time ( $\tau_{GD}^*$ ):

$$Y_{12} = Y_1 / \tau_{GD}^* \quad (4)$$

$$Y_{23} = Y_2 / \tau_{GD}^* \quad (5)$$

$$GR_O = Y_3/\tau_{GD}^* \quad (6)$$

$$\tau_{GD} = \tau_{GD}^*/3 \quad (7)$$

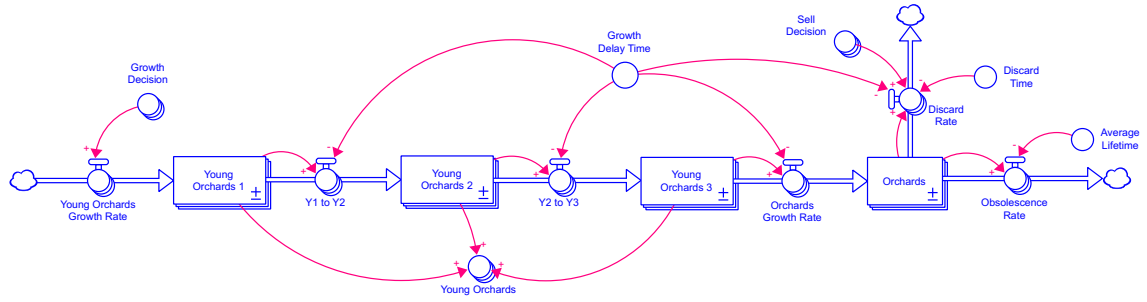


Figure 3. Implementation of the third-order delay on the orchard sector

## Recruiting process

In this section, we provide more details on the recruiting process on Amazon Mechanical Turk (MTurk). The first stage is to publish a Human Intelligence Task (HIT) containing a demographics survey, experiment instructions, and a qualification test. Figure 4 shows the first page a user sees when joining the survey link.

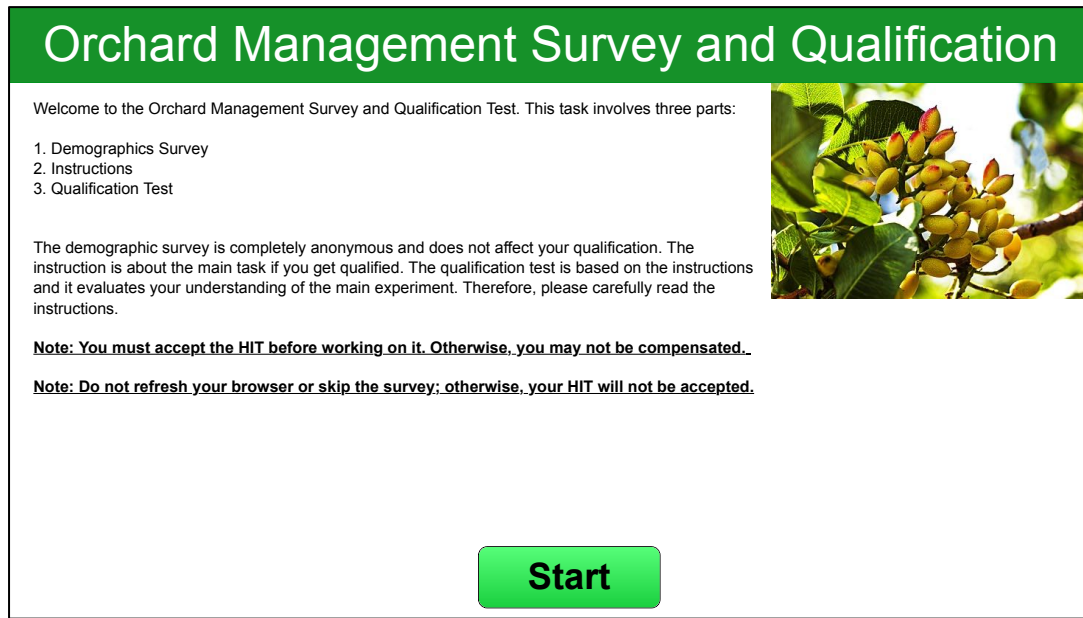


Figure 4. The first a page a user sees when joining the survey link.

## Demographics

The survey comes before the qualification test and the experiment. We used the following questions to gather data about the users potentially attending the experiments:

This survey is anonymous and your answer to these questions do **NOT** impact your qualification.

1. What is your age group?
  - a. Under 18
  - b. 18 – 24
  - c. 25 – 34
  - d. 35 – 44
  - e. 45 – 54
  - f. 55 – 64
  - g. 65 – 74
  - h. 75 – 84
  - i. 85 or older
2. What is your gender?
  - a. Male

- b. Female
- 3. What is your highest level of education?
  - a. Less than high school
  - b. High school graduate
  - c. Some college
  - d. 4-year degree
  - e. Professional degree
  - f. Doctorate
- 4. How much experience do you have working in the agriculture sector (e.g., manager, engineer)?
  - a. None
  - b. Less than 1 year
  - c. 1-3 Years
  - d. 3-6 Years
  - e. More than 6 years
- 5. What is your current employment status?
  - a. Student
  - b. Homemaker
  - c. Retired
  - d. Unemployed
  - e. Working Part-time
  - f. Working Full-time
- 6. How much is your annual gross income?
  - a. Under \$10,000
  - b. \$10,000-\$20,000
  - c. \$20,000-\$30,000
  - d. \$30,000-\$45,000
  - e. \$45,000-\$60,000
  - f. \$60,000-\$80,000
  - g. \$80,000-\$120,000
  - h. Over \$120,000

Figure 5 shows the graphical design of the demographics survey. To move forward, users must answer all survey questions. If a user leaves the survey incomplete and goes to the next page, they will see an error forcing them to go back and complete the survey (Figure 6).

# Orchard Management Survey

## Demographics

This survey is anonymous and your answer to these questions do NOT impact your qualification.

1. What is your age group?

☐ Under 18    ☐ 18-24    ☐ 25-34    ☐ 35-44    ☐ 45-54    ☐ 55-64    ☐ 65-74    ☐ 75-84    ☐ 85 or Older

2. What is your gender?

☐ Male    ☐ Female

3. What is your highest level of education?

☐ Less than high school    ☐ High school graduate    ☐ Some college    ☐ 4-year degree    ☐ Professional degree    ☐ Doctorate

4. How much professional experience do you have working in the agriculture sector (e.g., manager, engineer)?

☐ None    ☐ Less than 1 year    ☐ 1-3 Years    ☐ 3-6 Years    ☐ More than 6 years

5. What is your current employment status?

☐ Student    ☐ Homemaker    ☐ Retired    ☐ Unemployed    ☐ Working Part-time    ☐ Working Full-time

6. How much is your annual gross income?

☐ Under \$10,000    ☐ \$10,000-\$20,000    ☐ \$20,000-\$30,000    ☐ \$30,000-\$45,000    ☐ \$45,000-\$60,000    ☐ \$60,000-\$80,000    ☐ \$80,000-\$120,000    ☐ Over \$120,000

Submit and Go to Instructions

Figure 5. The demographics survey.

# Orchard Management Survey

**It seems that you have not responded to one or more than one questions of the survey. Make sure that all survey questions are responded. Please go back and answer all the survey questions.**

Go Back and Complete the Survey

Figure 6. Users cannot move forward if they leave the survey incomplete



## Experiment instructions

### Orchard Management Instructions

#### Information and Instructions

There are **four players**, including you, in this experiment. You will take the role of a pistachio orchards manager in an online simulation environment. The goal of this experiment is to assess your ability to manage your (simulated) orchard and profits. You will be paid based on your profit at the end of the simulation, consisting of **30 years (periods)**. The training round does not affect your compensation.

**Your Goal**

**Your goal is to maximize your profits (your bank account balance).** Profits are calculated as revenue minus costs. You will start with a budget of approximately \$10,000. You can increase your profits if you have more orchards, consequently more production and revenue. Everything you produce will be sold for \$100/Tonnes. **The pistachio price is fixed.** You can also earn money if you sell your existing orchards. However, orchards and water costs decrease your profit. Every year, you will pay \$20 for maintenance for each hectare you have, and you will pay for the water consumed for irrigating the orchards. You will pay a one-time \$40 for each hectare you grow.

Each hectare of **orchards (that produce pistachios)** requires 0.1 million cubic meters of water per year. Each hectare of **young orchards (while do not produce pistachios until they are fully grown)** requires 0.05 million cubic meters of water per year. The groundwater resources are shared among all farmers. If there is less water available, it is more difficult to extract water from the ground and the cost of water rises, which means you need to pay more for water to irrigate your orchards. If there is no water, there cannot be any pistachio production.

Note that you cannot invest and increase your orchards when you have negative profits (account balance). Moreover, you cannot sell orchards more than what you already have. For example, if you have 50 hectares of orchards and you decide to sell 100 hectares, you will only get paid for the 50 hectares.

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Figure 7. Information and instructions of the game

### Orchard Management Instructions

#### Governance Decisions and Profits

As a manager you make one decision each year:

**Decision for Orchard Growth/Sell:**

Every year you can adjust the orchard growth between -100 and 100 hectares per year. A positive number means orchard growth while a negative number indicates orchard sell. You will start with 100 hectares of orchards. You will be charged \$40 per each hectare you grow whereas you will receive \$25 per each hectare you sell to the government. **It takes less than 6 years to grow or discard a hectare of orchards.**

**How Much and When Will you Be Paid?**

Besides the survey, which pays \$0.25 to qualified users, your compensation for completing the second part of the experiment consists of three parts:

1. **Fixed payment:** You are guaranteed a fixed payment, shown on the MTurk instructions, for completing the simulation.
2. **Effort Bonus:** You will be paid an additional bonus between 0 and \$0.5 based on your efforts during simulation. Effort is estimated based on your deliberation times and thoughtful exploration of the decisions.
3. **Performance Bonus:** You will be paid an additional bonus of \$1 if you have the highest profit at the end of the experiment.

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Figure 8. Further instructions and information about the incentives

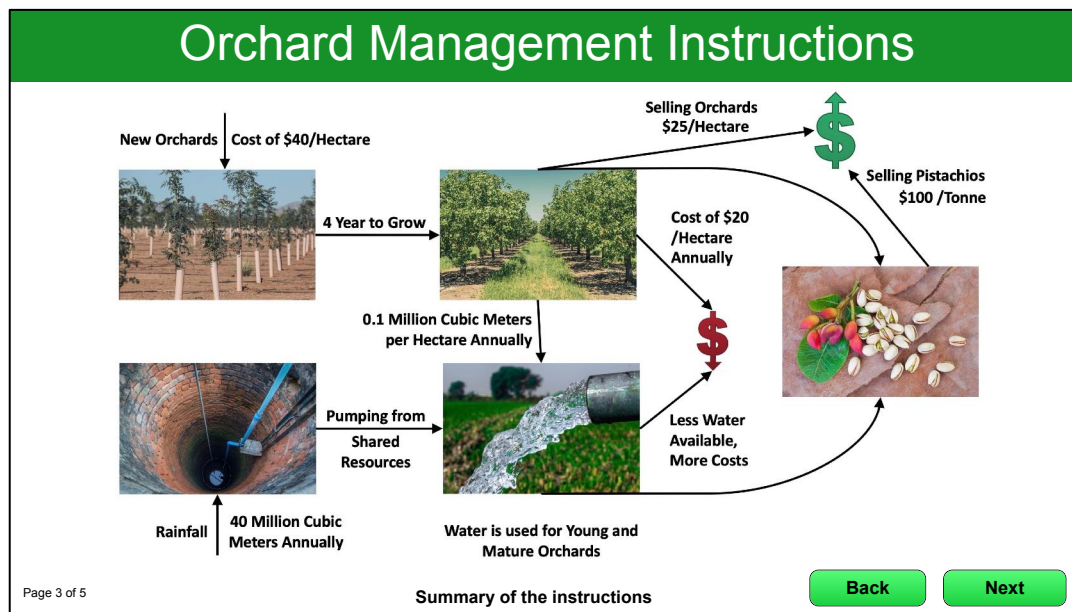


Figure 9. Summary of the instructions, visualized to provide a better overview

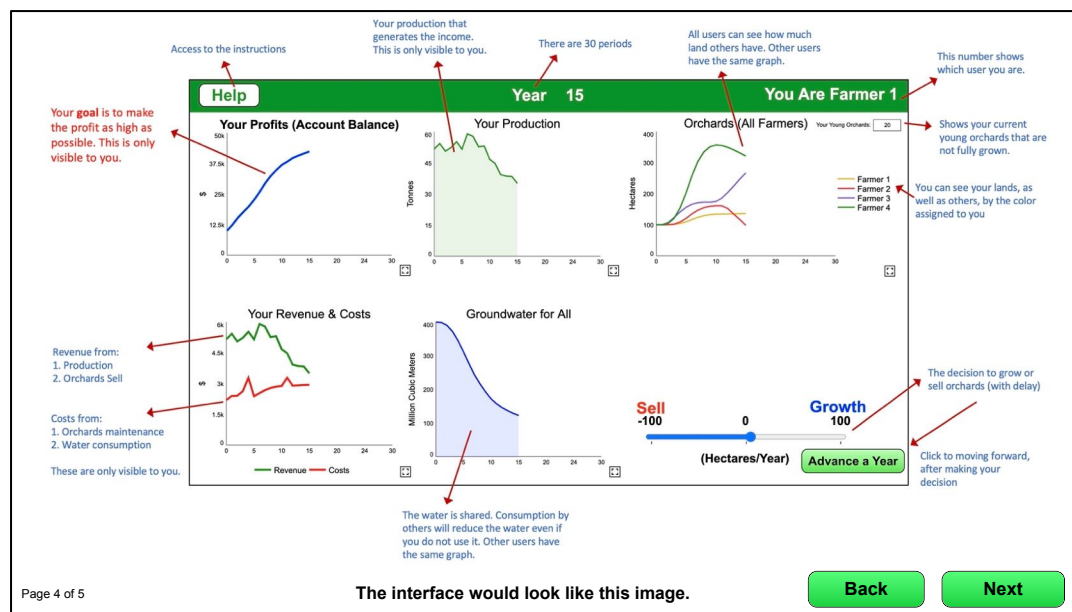


Figure 10. Interface instructions.

# Orchard Management Instructions

## User Interface

The items on the screen are explained below:

1. Profits Graph shows your accumulated profit.
2. Production Graph shows your annual production based on the orchard area you have.
3. Orchards Graph shows the orchards area for each farmer, including yours.
4. Revenue & Total Costs Graph shows your revenue and costs based on your production and the orchards and water costs.
5. Groundwater Graph shows the water available to all.
6. Orchard Growth/Sell Slider determines the area of orchards you decide to grow or sell for the next round.
7. Ready to Advance Button makes you ready to move forward to the next year. You may need to wait for other users to make their decisions.
8. Year shows the current time of the simulation. The simulation lasts for 30 years.
9. Instructions button provides the instructions at any stage of the experiment.

Note: Your profits, revenue, costs, and production are **ONLY** visible to yourself

Figure 11. More information on the interface

## Qualification test

We assess a subject's understanding of the experiment instructions using a few basic and very simple questions based on the instructions shown in the previous steps.

## Orchard Management Qualification Test

[Instructions](#)

**Qualification Test**  
Right answers to these questions qualify you for the main experiment.

1. What variable are you trying to maximize in the orchard management simulator?

☐ Orchards ☐ Profits ☐ Groundwater

2. Which graphs would you see in the user interface of the experiment? Select all that apply

☒ Profits ☒ Orchards ☐ Orchards Costs ☐ Production ☐ Groundwater ☐ Water Costs

3. How long will it take to fully grow your orchards?

☒ Less than 6 years ☐ Between 10 to 14 years ☐ Between 15 to 19 years ☐ Between 20 to 24 years

4. What decision do you control in the experiment? Select all that apply

☐ Temperature ☐ Orchards Growth ☐ Demand ☐ Orchard Sell ☐ Price

5. Final value of which factors determine your compensation? Select only one

☐ Price ☐ Demand ☐ Profit ☐ Production

6. How long does the simulation last?

☐ 10 Years ☐ 20 Years ☐ 30 Years ☐ 40 Years

7. Does the price change in the simulation?

☐ Yes ☐ No

8. How many players are will be in the simulation, including you?

☐ 1 Player ☐ 4 Player ☐ 8 Player ☐ 16 Player

9. Does water consumption by others affect the water available to you?

☐ Yes ☐ No

[Submit](#)

Figure 12. Qualification test

## Orchard Management Survey and Qualification

Unfortunately, you did not qualify. Thank you for participating in this survey.

You can attend the survey again using the original link.

Figure 13. Message received by unqualified users

## Orchard Management Survey and Qualification

**Congratulations! You are qualified.**

Your Code	0
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Thank you for participating in this survey.

Please submit the generated code on MTurk so that we can compensate you.

We will post other HITs regularly to ask you to attend the original experiment.

You can now close the browser page.

Figure 14. Survey code received by qualified users

# Experiment Interface

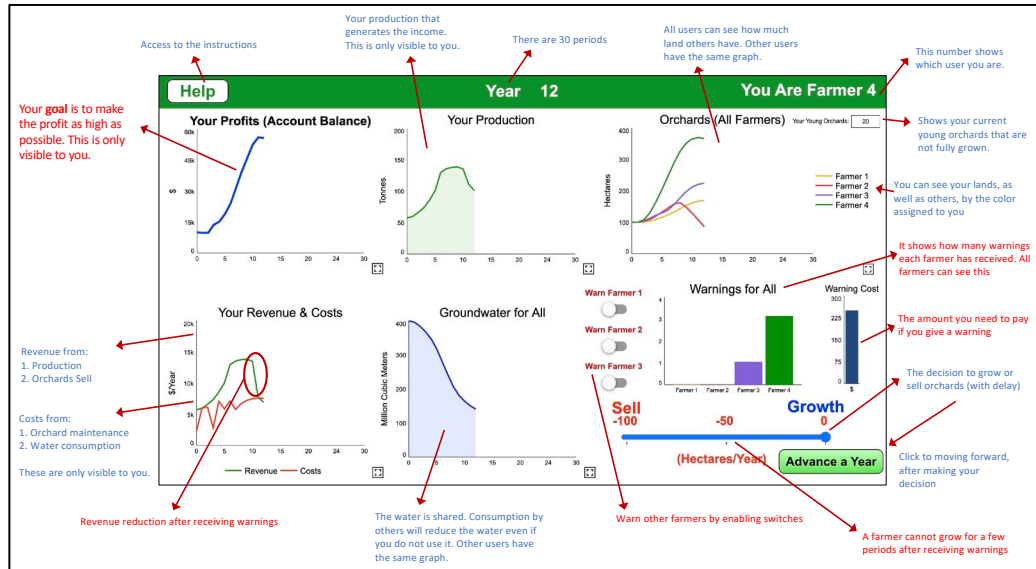


Figure 15. User interface with punishment

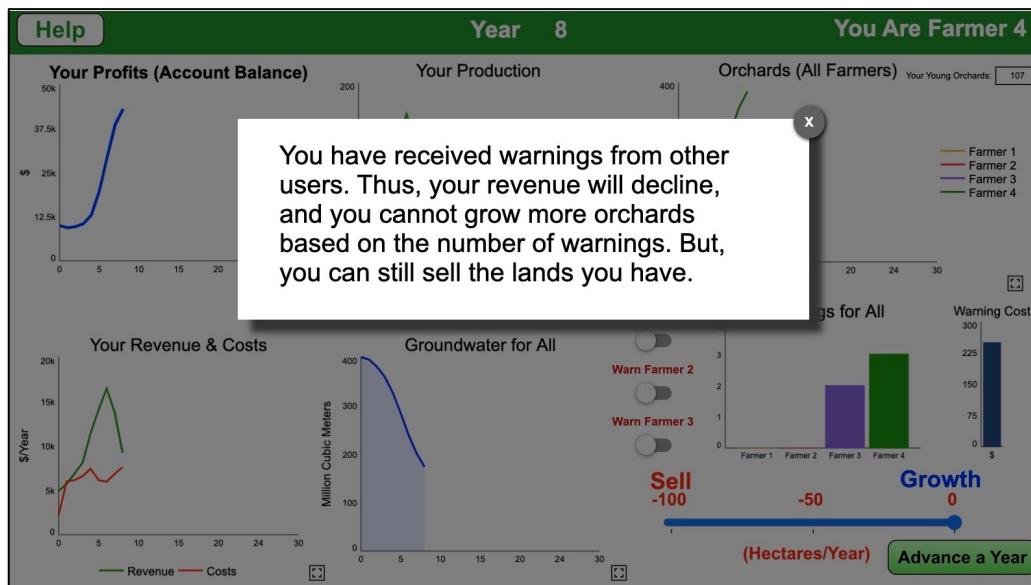


Figure 16. Message shown to a subject when their punishments received goes above the threshold

## References

Tsur, Y., & Zemel, A. 2004. Endangered Aquifers: Groundwater Management Under Threats of Catastrophic Events. *Water Resources Research*, 40(6).