**Seeds of Learning: Ecosystem-Based Adaptation Interactive Game Instructions**

You are a small-scale farmer in a rural region of a developing country. You are a subsistence farmer: your crops feed your family, and thus your crop yield is crucial to your family’s wellbeing. Climate change is causing an increase in extreme precipitation and temperature patterns where you live. As a result, the agriculture that you and your neighbors practice is increasingly threatened by hazards such as drought, flooding, and extreme heat.

Your government would therefore like to encourage some people in your community to adopt ecosystem-based adaptation (EBA) practices to reduce erosion and improve water quality, soil quality, and agriculture in your area. EBA practices include changes to landscape configuration (terraces, contours, and bunds), different ways of working the soil (e.g., low-till or no-till), different inputs (improved seeds, mulch, organic fertilizer instead of traditional, and reduced fertilizer use), agroforestry, intercropping, and preservation of small strips of land along waterways to filter runoff (riparian buffer strips). Over a series of periods (each of which represents a growing season), the government will offer conservation contracts; the contract in each period will offer you a payment if you adopt the EBA practice the government proposed for that period.

Each practice requires you to put in a lot of work to implement it. We represent this as an adoption cost of 1,000₼ (your country’s currency, which is known as shillings). Each practice reduces erosion, and each (in ways we will describe) affects your crop yield directly and affects everyone in the community indirectly by improving the ecosystem.

The direct effect on your yield comes from reduced erosion and other features of the practice; for example, some practices reduce the amount of your land you can grow crops on. The net direct effect may be positive or negative, and may be a known amount or may be uncertain. The direct effect depends on the specific practice, and will be described in each contract period.

Your adoption of an EBA practice provides ecosystem services because reduced erosion reduces sedimentation and pollutants in waterways and diminishes the force of flowing water. Thus, if one person adopts any EBA practice, other farms have improved water and soil quality and themselves experience less erosion. Specifically, each person’s adoption of any EBA practice increases the yields of everyone in the community by 5%. For example, if 10 farmers adopt a practice, everyone’s yields go up by 10\*5% = 50%. We’ll call this the *ecosystem yield increase rate*. If you are an adopter, this indirect effect is additional to the direct effect the practice has on your yield.

We will play through several contract periods, with specific circumstances changing in ways that we will describe below. In each year, your earnings are the sum of your *farming earnings*, your *adoption costs*, and your *government payments*. You were handed a card at the start of today’s session. Your *Farming Value*, the value of the crop yield you get if no-one adopts an EBA practice, is 1,000₼ times the value on your card. Your *farming earnings* come from your *Farming Value*, adjusted by direct and indirect effects from the conservation practices you and your neighbors adopt. The *adoption costs* are 1,000₼ if you adopt the practice and 0₼ if you do not. The *government payments* vary across contract periods: there is either no government payment, a flat payment for adopters, or a payment based on an auction (which we will describe later).

In each contract period, you must make a decision: whether to adopt the EBA practice (or what bid to make in an auction to determine who adopts the practice). Your earnings for that period depend on your decision and the decisions of the other people in the community.

The table below translates the possible per-period earning ranges in this game into ways a low-income family in a situation like this might experience those levels of earnings.

|  |  |
| --- | --- |
| **Per-period earnings** | **Your family’s experience** |
| Less than 2,000₼ | Family is hungry; it cannot afford basic necessities; health suffers; children are removed from school at a young age |
| 2,000₼ to 5,000₼ | Basic necessities are met; can afford some schooling for children; but a life shock (e.g., major illness) can push the family into deep need |
| 5,000₼ to 10,000₼ | Basic necessities and health are covered; children can attend school |
| Above 10,000₼ | Can save money or start a business; children can attend university |

Your earnings for the whole session are the sum of your earnings in each period. To ensure that each person makes thoughtful decisions, at the end of the game we will randomly choose one or more people (the instructor will announce how many) and pay them an amount based on their total earnings (the sum of earnings for all periods converted to dollars by dividing by 10,000₼/$).

**Contract Period 1: No Government Involvement**

The EBA practice the government would like you to adopt is a riparian buffer strip: keeping an uncultivated buffer of land along river banks. Adoption directly *reduces* your yield by 10%.

The government is offering no payment.

Therefore, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%) – Farming Value \* 10% – 1,000₼

If you do not adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

**Contract Period 2: Flat Adoption Subsidy**

The EBA practice is again a riparian buffer strip, and its direct effect on your yield if you adopt it is to *reduce* your yield by 10%.

The government will pay 1,500₼ to each person who enters a contract to adopt the EBA practice. Since adoption costs 1,000₼, this means that if you adopt, in addition to your farming earnings you get 1,500₼ – 1,000₼ = 500₼.

Therefore, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%) – Farming Value \* 10% + 500₼

If you do not adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

**Contract Period 3: Conservation Auction**

The EBA practice is again a riparian buffer strip, and its direct effect on your yield if you adopt it is to *reduce* your yield by 10%.

The government will pay for adoption of an EBA practice, but now it will choose conservation contract recipients and the subsidy amount based on a conservation auction.

Therefore, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%) – Farming Value \* 10%
– 1,000₼ + Government Payment

If you do not adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

As noted, contracts will be awarded this period through an auction. Instead of declaring whether you’d like to adopt the adaptation practice, you will instead declare a bid. The government asks you to bid the minimum amount of money you’d be willing to accept to adopt the practice. Once everyone has made a bid, the government will rank the bids and will accept the lower half of them (all bids asking for up to the median bid). The government payment for all accepted bids will be the lowest bid that was *not* accepted. For example, if the bids were 1₼, 2₼, 3₼, 4₼, and 5₼, bids 1₼, 2₼, and 3₼ would be accepted and the payment for all of them would be 4₼.

**Contract Period 4: Uncertain Direct Effect**

The EBA practice is now low-till farming. This practice has different direct effects on your yields in different years, because the effects depend on the weather, although it has the same ecosystem-based water and soil quality benefits for everyone in every year (5% increase times the number of adopters in the community). In a good year, the practice will increase yield by 10%, but in a bad year, it will decrease yield by 30%. Good years and bad years are equally likely (50% chance). We call this amount the *Weather Yield Adjustment*. Everyone will have the same *Weather Yield Adjustment* (in percent) in this contract period. We will use the random number generator in Excel to determine the weather this year and thus the effect on everyone’s yields, but only after everyone has made their decision.

The government will pay 1,500₼ to each person who enters a contract to adopt the EBA practice. Since adoption costs 1,000₼, this means that if you adopt, in addition to your farming earnings you get 1,500₼ – 1,000₼ = 500₼.

Therefore, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)
+/– Farming Value \* (Weather Yield Adjustment) + 500₼

If you do not adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

**Contract Periods 5A & 5B: Uncertain but Correlated Direct Effect**

The EBA practice is now agroforestry, with trees planted in borders surrounding the crops. This practice takes land away from cropping and the trees will use water and nutrients that the crops would otherwise use. On the other hand, the trees will provide a windbreak and will anchor the soil, and thus reduce erosion. The trees may also provide local cooling and may make water more available to your crops. Studies have found varying effects of these benefits on yields; the results also may depend greatly on factors like the soil type, elevation, and gradient of the land. Scientists do know that agroforestry will generate the same water and soil quality benefits as the other practices (5% increase times the number of adopters in the community), but the direct effect on adopters’ yields could be to *increase or decrease* your yield by an amount we will call the *Unknown Yield Effect*.

This Unknown Yield Effect will vary from field to field, but the general tendency will be the same across all fields in a local area. To be precise, the Unknown Yield Effect will be normally distributed around some mean (average) value, and that mean value will be either -30% (Low Type) or +10% (High Type). Both are equally likely; that is, each is 50% likely. This means that there is a high chance of getting values that are close to the mean and a small chance of getting values that are more different. Therefore, if you see someone else’s yield effect from agroforestry, that tells you something about how it will work on your land, though your exact effect will probably be different. In other words, you don’t know the effect agroforestry will have on your farming until you try it; you don’t even know the precise mean value of the distribution of possible effects, but can learn about it from seeing others’ yield effects.

The figure below will help you visualize these random effects. There are two lines on the figure (Low Type and High Type); each represents one the way that farmers’ values for agroforestry might be distributed in a local area. The height of the line shows how common a value is in the given community. The mean of the distribution is where the line peaks. As you can see, each has distribution a different mean (average) but has some values larger and some smaller than the mean. Everyone in your community will have a value from the same distribution, but you don’t know yet which distribution applies in your community. Not only that, you don’t know where on the distribution your own personal effect will be. For example, if your community has a Low Type distribution, you could be more like Farmer 2, than Farmer 1, or Farmer 3.

We will use Excel’s random number generator to determine the mean effect and each person’s individual effect, but both will be hidden; only the Unknown Yield Effect for people who adopt agroforestry will be revealed.[[1]](#footnote-1)

The government will pay 1,500₼ to each person who enters a contract to adopt the EBA practice. Since adoption costs 1,000₼, this means that if you adopt, in addition to your farming earnings you get 1,500₼ – 1,000₼ = 500₼.

We will play this treatment for two periods, and you need not make the same decision in both periods. Your Unknown Yield Effect will stay the same across the two periods! That is, we’ll use Excel to come up with random numbers at the beginning of period 5A, and those numbers will apply to both 5A and 5B.

In each period, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%) +/– Farming Value \* (Unknown Yield Effect) + 500₼

If you do not, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

**Contract Periods 6A & 6B: Uncertain but Correlated Direct Effect, with Pilot Bonus**

The EBA practice again uses trees, but in this case through intercropping: you are being encouraged to plant trees at regular intervals within your crop fields. The benefits and costs of intercropping with trees are similar to those of planting tree borders around crop fields. However, the net effects are again uncertain and may be entirely different from the effects of the tree borders: both the costs and benefits are distributed broadly rather than concentrated around the edges of the field. Different plots of land will respond differently to intercropping as compared to agroforestry, because the two systems perform differently in response to different sizes, shapes, and elevation patterns on a plot of land. As a result, there is the same kind of uncertainty about intercropping’s effects on yields as there was for border agroforestry. There is some unknown mean effect, which will be either -30% (Low Type) or +10% (High Type). Both are equally likely; that is, each is 50% likely. Again, everyone has a personal difference in effect drawn from a distribution with that mean, and your personal value is your Unknown Yield Effect. We will determine both the mean and the individual effects with Excel’s random number generator. Both the mean and the personal difference will be different from the values you saw with border agroforestry.

The government will pay 1,500₼ to each person who enters a contract to adopt the EBA practice in each period. Since adoption costs 1,000₼, this means that if you adopt, in addition to your farming earnings you get 1,500₼ – 1,000₼ = 500₼.

What’s different now is that the government is offering an additional pilot bonus of 500₼ to people who adopt the conservation practice *in the first period*. The goal is to help everyone learn more about the effect of this practice.

We will play this treatment for two periods, and you need not make the same decision in both periods. Your Unknown Yield Effect will stay the same in both periods! That is, we’ll use Excel to come up with random numbers at the beginning of period 6A, and those numbers will apply to both 6A and 6B.

In each period, if you adopt the practice, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%) +/– Farming Value \* (Unknown Yield Effect) + 500₼ + Pilot Bonus

where the Pilot Bonus is 500₼ in the first period, and 0 in the second period.

If you do not, your earnings are:

Earnings = Farming Value \* (1 + # adopters \* 5%)

**Recording Sheet**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Your Card Value: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Player: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Note: the column references here refer to the columns of this recording sheet, not the earnings spreadsheet we’ll use in class!

 

1. Don’t worry that your earnings might go negative; we are truncating the distribution so that cannot happen. [↑](#footnote-ref-1)