

# Value of Science 105: Three Principles of the Value of Information

Explainer by **Yusuke Kuwayama** — June 2021

As we learned in [Value of Science 102](#), projects and programs that produce new information can yield important societal benefits. These benefits are the improvements in outcomes that matter to people and the environment—lives saved, increased crop yields, a fishery collapse avoided—that result from making better decisions. From this basic concept, we can derive three principles of the value of information:

1. New information can yield societal benefits only if it influences a decision.
2. These benefits are likely to be largest when the information greatly reduces uncertainty and enables actionable decisions with big impacts.
3. We can quantify these benefits in socioeconomic terms by identifying the changes in decisions and outcomes associated with the improvements in information.

## Decisions, Decisions

Many kinds of new information improve our understanding or reduce our uncertainty regarding a human or natural system. But this improved understanding, while potentially having scientific value, will translate to socioeconomic value only if the information is paired with a decision. Taking this concept a step further, measuring the value of scientific information requires a clear understanding of the decision contexts that use the scientific information.

Imagine a scientist who aims to quantify and communicate the benefits of an improved water quality forecasting system. A natural starting point to express the value of this information might be to say,

“An improved forecast can help inform water quality management.” But this statement is too vague in the context of valuing information because it doesn’t tie the information to a specific decision. Here’s a more detailed alternative: “An improved harmful algal bloom forecast will help managers of recreational areas along Utah Lake issue more timely warnings to visitors so they are not exposed to toxins in the algal blooms.” In this framing, we understand the socioeconomically meaningful outcome (i.e., the reduction in exposure to toxins and associated human health impacts) and the specific decision context (i.e., management of freshwater recreational areas).

## When Is the Value of Information Likely to Be Large?

The second principle helps identify decision contexts in which the benefits of improved information are likely to be large, using the following two key indicators.

**Indicator #1:** The new information needs to lead to a meaningful reduction in uncertainty. After all, uncertainty regarding the state of something, or regarding the consequences of an action, is the reason why scientists seek to produce new information. As an example, consider two kinds of new information—one kind that adds information about something that we know very little about, and another kind that adds information about something for which there is already a vast body of knowledge. The former is more likely to lead to a greater reduction in uncertainty for a decisionmaker.

**Indicator #2:** The decision must be actionable and tied to very positive and very negative states of the world. New information must feed into a decision context in which the decisionmaker can choose among actions that influence the outcome, and the outcomes must vary in desirability. To put it another way, for information to be valuable in a decision, the stakes must be high. Information is not likely to be valuable if you can't choose actions based on the information, or if the actions available to you don't make much difference to the outcome.

Take a costly asteroid prediction system as an example. Suppose that this prediction system is highly accurate, so that Indicator #1 is satisfied—the system greatly reduces uncertainty about whether a nearby asteroid is going to impact Earth. The asteroid prediction system is also clearly providing information about something with very positive and very negative states of the world. If the asteroid bypasses Earth, life goes on; if it collides with Earth, catastrophe ensues. So, does this asteroid prediction system provide large benefits to society? It all depends on the availability of actionable decisions. If asteroid impact avoidance measures can be activated, then information from the prediction system might be valuable because it gives us a chance to avoid an impact and catastrophic outcomes. But if we can't take any effective actions in response to the knowledge of an impending asteroid collision, Indicator #2 is not fully satisfied, and the information from the prediction system will not generate significant societal benefits.

## Measuring the Societal Benefits of Improved Information

In this explainer, we have referred to “better” decisions and “improved” outcomes. These words imply some sort of change—a “delta” we need to identify in order to characterize the value of information. The “deltas” are changes in decisions and associated changes in outcomes. Our final principle underpinning the value of information is that we can use these “deltas” to quantify the societal benefit that results because improved information is available.

Let's return to the example of an improved forecasting system for harmful algal blooms in Utah Lake. We can

measure the socioeconomic benefits of this information using a framework that compares the “deltas” between two scenarios—one in which the new forecasts are available, and one in which they are not.

In the first scenario, managers decide to close the affected recreational areas along Utah Lake based on the improved forecast, which prevents people from getting exposed to a harmful algal bloom and becoming sick. In the second scenario, the information isn't available, managers keep these areas open, and people get sick. The difference in human health outcomes between these two scenarios represents the benefit of the improved forecasts.

### Example from VALUABLES: Monitoring Harmful Algal Blooms

In a VALUABLES impact assessment published in the journal *GeoHealth*, [Stroming et al. \(2020\)](#) used this exact approach to estimate the socioeconomic benefits of satellite remote sensing for detecting cyanobacterial harmful algal blooms (cyanoHABs) and managing recreational advisories at freshwater lakes. Specifically, the study concludes that the satellite data resulted in a change in decisions by lake managers that led to closure of the lake seven days earlier than what would have taken place without the satellite data. The change in outcome was that 400 fewer people experienced symptoms of illness thanks to the change in the decision. These “deltas”—the earlier closure of the lake and the reduction in illnesses—represent the societal benefits of the satellite data.

This type of analysis is called a Value of Information impact assessment. These rigorous, quantitative studies investigate how people use improved information to make decisions and quantify how these decisions improve socioeconomically meaningful outcomes.

In the next several explainers, we will introduce the framework in more detail and explain how to conduct impact assessments, arming Earth scientists with a powerful tool for quantifying and building awareness about the socioeconomic benefits of satellite data and other Earth observations.

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