Sustaining the Commons

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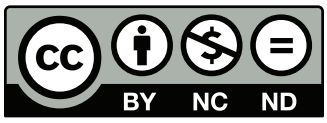


In memory of Elinor Ostrom

Preface

In October 2009 the Nobel committee announced that political scientist Elinor Ostrom would receive the Nobel Prize in Economic Sciences, together with economist Oliver Williamson, "for her analysis of economic governance, especially the commons." Many people had never heard of Elinor Ostrom. In fact, many economists, including New York Times columnist and Nobel Laureate Paul Krugman, were not familiar with her work. Some people noted that Ostrom's winning of the Nobel Prize was even more controversial than President Barack Obama's winning of the Nobel Peace Prize that year.

What was the controversy all about and why did Ostrom's discoveries warrant a Nobel Prize? Ostrom's work showed that a traditional approach in economics to the study of the management of shared resources (e.g., public infrastructure, common-pool resources) was incomplete. The conventional approach assumed that when people share a resource, such as ground water, fish or a forest, everyone acts in their own self-interest leading to overharvesting of the shared resource. The only way to avoid this so-called "tragedy of the commons"[1] is to establish private property rights or tax the use of the shared resource.

In a series of studies over several decades with many colleagues around the world, Ostrom showed that people are able to self-organize and successfully govern their shared resources. Her analysis provides insights into the conditions under which self-governance is possible. These findings have major implications for policy and can help explain the ineffectiveness of many policies and governance regimes.

Ostrom's winning of the Nobel Prize was not only controversial because of the nature of her research. She was also the first female to win the Nobel Prize in Economic Sciences. All her official degrees were in Political Science, although she had minors in Economics. Her work was published in top journals, but was less well known among traditional economists. In fact, Ostrom worked across many disciplines, using qualitative and quantitative methods to address questions relating to the governance of resources that affect the most vulnerable people in the world.

The theoretical framework she developed over her career is applicable to the study of the governance of shared resources in many different contexts including the "digital commons," health care, and education. Her Nobel Prize increased the attention this line of work received from other scholars and earned her a listing among the top 100 most influential people in the world by *Time Magazine* in 2012, just before her death on June 12, 2012.

This textbook will present the main intellectual framework, concepts, and applications of the work of Elinor Ostrom and her colleagues to an undergraduate audience. Because of our belief in the importance of Ostrom's work and a desire to share it with a broader audience, we started teaching a course on collective action and the commons in 2007 at Arizona State University. Initially we made use of Ostrom's classic book *Governing the Commons,* but this book was not written for an undergraduate audience. Moreover, many new insights have emerged since the publication of *Governing the Commons* in 1990. Therefore we decided to write our own textbook, which we have been using since the spring of 2012.

We worked with "Lin," as she preferred to be called, from 2000 until her death. We collaborated on various projects focused on the governance of the commons, especially on questions related to robustness. Lin Ostrom had been a professor at Indiana University for her entire career starting in

[1] Note, shared resources are often erroneously referred to as the "commons." In fact the "commons" refers not to a resource, but a type of governance regime employed in Medieval Europe. Unfortunately this erroneous usage has persisted in the literature and now the term "commons" is used to refer to a shared resource of some type over which there is no governance regime—i.e., the resource is "open access." We use the term "commons" in this sense in this book

1965, and beginning in 2006 she held a part-time appointment as a research professor at Arizona State University in order to collaborate in what is now called the Center for Behavior, Institutions and the Environment, which we direct. Lin Ostrom also gave several guest lectures to the class for which we developed this book.

This book is aimed at students who are interested in studies related to sustainability challenges. To illustrate the concepts, we will use examples mainly from sustainability but will include several everyday topics to build intuition. During a course based on this book, you will learn about institutions—the rules and norms that guide the interactions among us and the environments that sustains us. These rules and norms range from traffic rules, rules in sports, and regulations on when and where alcohol can be consumed to constitutional rules that define how much tax you need to pay and who can become president. Rules and norms help guide us to cooperative outcomes of so-called collective action problems. If we rely only on voluntary contributions alone to get something done, we may not achieve the best results. But research also shows that coercive tactics to force people to comply with strict rules does not necessarily lead to good outcomes either. What combination of sticks and carrots is needed to successfully solve difficult collective action problems such as governing shared resources or, as you might see it put in the literature, "sustaining the commons"?

There is no simple formula for determining the best set of rules. Unfortunately, context matters, so every situation is different. Nonetheless, we can develop our understanding of how context matters to help us interpret different situations and how to address them more effectively. In this book you will become familiar with a framework to study the norms and rules necessary to solve collective action problems in order to sustain the commons. We will also consider how to evaluate the success of the rules, for whom the rules hold, and who can craft the rules? We see that the ways in which people can create and adjust rules and norms affects the success of those rules. We will discuss what insights we can derive from a deep understanding of rules and norms that may be helpful for finding solutions for sustainability challenges.

This book is based on the work of Elinor Ostrom, particularly the 1990 book *Governing the Commons* and the 2005 book *Understanding Institutional Diversity*. The way we present the material is based on our teaching of it as an undergraduate course at Arizona State University. We have included many contemporary examples of institutions and commons that were not part of Ostrom's original publications, but that help to explain and clarify the concepts. Providing many different examples also illustrates the wide applicability of Ostrom's work beyond her main applications in the area of natural resource management.

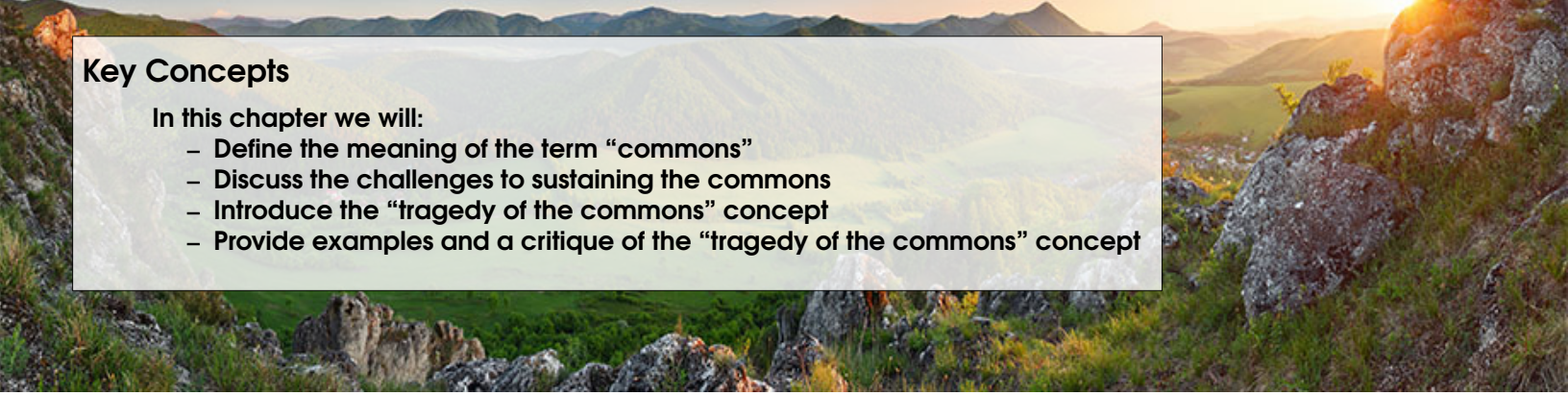
In deciding how to publish this book we considered several different options and eventually chose to give it away as a contribution to the knowledge commons. We would like to hear from you regarding what you think about the book. On the website sustainingthecommons.asu.edu we have a blog where we post relevant examples on different commons we come across in our research. Let us know if you come across interesting examples.

We would like to thank our students and teaching assistants who participated in classes where we used earlier versions of this manuscript for providing helpful feedback. We would also like to thank Jennifer Fraser for her careful editing, Nathan Rollins for his help in the publishing process, and the National Science Foundation for financial support. When we started working on this project Lin was part of it. She saw the first draft we wrote in April 2012, and she was very pleased with it. Her passing made us even more motivated to continue the project. Therefore we dedicate this text book to the memory of our mentor and friend Lin Ostrom.

Contents

Part I

Theoretical background



Key Concepts

In this chapter we will:

- **Define the meaning of the term "commons"**
- **Discuss the challenges to sustaining the commons**
- **Introduce the "tragedy of the commons" concept**
- **Provide examples and a critique of the "tragedy of the commons" concept**

1 — Why Study the Commons?

U.S. Infrastructure Gets a D+

According to the prestigious American Society of Civil Engineering (ASCE), our roads, dams, water systems, airports, and other infrastructure are in bad shape. In their 2013 assessment, the ASCE gave U.S. infrastructure a D+. In especially bad shape are the nation's levees and inland waterways; they both received a rating of D-.

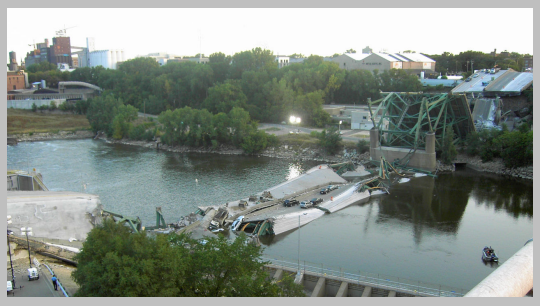


Figure 1.1: During the evening rush hour on August 1, 2007 the I-35W Mississippi River bridge collapsed killing 13 people. Federal inspection had ranked the bridge structurally deficient, like about 70,000 other bridges in the U.S.

What would the U.S. need to do to get a better grade on the state of its infrastructure? The answer is that it would need to invest heavily in its infrastructure. In fact, ASCE suggests that $3.6 trillion needs to be invested by 2020 to bring the U.S.'s infrastructure up to good standards.

Recent tragedies caused by Hurricanes Katrina and Sandy illustrate the importance of investing in the maintenance of infrastructure and the consequences of not doing so. It is the responsibility of society at different levels (federal, state, and local) to make judgments about how much to invest in the infrastructure that we all share (by increasing taxes or redirecting spending) and whether to reduce taxes, giving more resources to individuals to expend as they see fit. Will individuals voluntarily invest in building and maintaining critical infrastructure?

For a wealth of information regarding the state of U.S. infrastructure and the challenges ahead, visit www.infrastructurereportcard.org.

1.1 What are the commons?

The original meaning of the term "commons" comes from the way that communities managed shared land in Medieval Europe. This shared land was not owned by any single individual but, rather, was "held in common," thus the term "commons." Along with this shared land was a clear set of rules developed by the community about how it was to be used. Technically, the term "commons" thus refers to the land and the rules that go with it to govern its use. Over time, the term commons has taken on several meanings. Most generally it can be used to refer to a broad set of resources, natural and cultural, that are shared by many people. Examples of resources that are referred to as "commons" include forests, fisheries, or groundwater resources that are accessible to members of the

community. The key term here is "shared." Forests, for example, need not be shared—there are many examples of private forests. Thus, implicit in the term "commons" as it is frequently used today is that there are no property rights established over the resource. That is, the resource is "open access." This departs somewhat from the original meaning and has, unfortunately, caused some confusion as we shall see later. Other examples of commons that the reader will encounter in everyday life include open source software, Wikipedia, public roads, and public education. Throughout this book, we will use the term "commons" to refer to a resource, or collection of resources over which private property rights have not been established.

Regardless of how they are managed, these examples show that the types of resources that can be defined as "commons" are essential for our society. We share them, inherit them from previous generations, and create them for future generations. The commons are therefore crucial for our wealth and happiness.

Why would we care to study the commons? In this chapter we will explain that there is a big challenge associated with sustaining the commons. Because of the lack of clear rules of use and mechanisms to monitor and enforce those rules, some commons are overharvested. Examples include fishers fishing the oceans in international waters, farmers pumping up groundwater, or movie watchers using the limited bandwidth of the community internet connection, reducing data availability for other users. How can we make sure that the commons are used wisely and fairly? Who should regulate the use of the commons? Who should make the rules? In the original commons in Medieval Europe the answer to these questions was clear: the community that held the land in common made the rules and enforced them to regulate the use of the commons. In modern commons, where the resources in question are typically much more complex, answering these questions is much more difficult.

As of this writing we are teaching a course in Beijing where, when we walk on the streets, we often have to wear masks to protect ourselves from air pollution. This experience is a powerful reminder that the air we breathe is part of a commons. As individuals we have no control over the pollution in the air and, as a result, of the quality of the air we breathe because there are no comprehensive property rights governing access to the atmosphere. In some cities the air quality is dangerously bad, while in others the sky is blue and there are no measurable pollutants. What underlies these differences? Is this due to regulation, population density, or the geography of the landscape? What are the costs and benefits of improving air quality and who will lose and who will gain from such changes? Who is making the decisions on activities that affect air quality? So the type of question that is of interest to people who study the commons is "what enables some groups to successfully resolve commons problems and what prevents others from doing so?"

In this book, we will discuss many successes and failures regarding governing the commons. We will introduce a framework that can be used to help us analyze the various types of commons that are so important to our well being and illustrate how it can be used to provide a better understanding of how to better govern our shared resources. There is no silver bullet solution that will always lead to the outcomes we desire, but we can learn about mechanisms that increase the likelihood of desirable outcomes.

How to effectively govern the commons has been a long debate in academia. Over the last 40 years, the traditional approaches to solving the commons problem through privatization or state regulation have been challenged. The next section will introduce the basic elements of the debate, the controversy that has arisen around it, and some alternative solutions.

1.2 The tragedy

In 1968, biologist *Garrett Hardin* (Figure 1.2) wrote a famous essay in the journal *Science* titled "The Tragedy of the Commons." Garrett Hardin was an American ecologist who warned of the dangers that the increasing human population would impose on the environment. He argued that when people share a resource they will overharvest it because it is in their individual interest to take as much as possible.

Hardin used the metaphor of sheep herders sharing an open-access pasture. He erroneously referred to this open-access shared resource as a "commons" (if it were really a commons the community would use a common-property governance regime to regulate access—more on this later). The title of his paper should have been "The Tragedy of Open-Access." Unfortunately, this use of the term "commons" stuck and, in fact, has had unfortunate consequences, as we will see shortly. Because there are no restrictions on the use of the pasture, each herder can benefit as an individual by adding extra sheep. Unfortunately, if all the herders add sheep, as a group they will eventually bear the costs of the additional grazing, especially when it creates a situation in which the total number of grazing animals consumes grass faster than the pasture can regenerate new grass. The effect of overgrazing is shared by all herders, but the benefit of adding extra sheep goes to the sole owner of the sheep (as long as other herders do not add too many sheep).

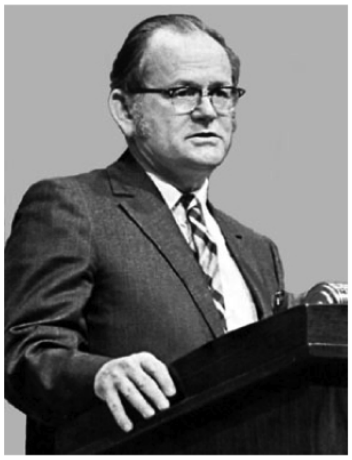


Figure 1.2: Garrett Hardin

Based on the reasoning that people are rational selfish actors, any time the benefits of using a shared resource are private and the costs are shared we can expect the commons will be overgrazed. Hardin formulates this as follows:

> Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all (Hardin, 1968, p. 1245).

The observation that people cause problems for to the common good when they follow their self interest is not new. The Greek philosopher Aristotle noted more than 2000 years ago that "what is common to the greatest number has the least care bestowed upon it." The reason that Hardin's argument got so much attention was due to his recognition that the concept can be applied to many modern environmental problems. With the emerging interest in environmental conservation in the 1960s, he provided an explanation for why we were causing so much damage to the environment.

Hardin concluded that there were only two options to avoid the depletion of the commons. One option was to give the herders private property rights. If each herder owned a piece of the common land and the herder's sheep caused overgrazing and erosion, the costs would be felt by the individual herder only. For this reason, the rational herder would choose to put an appropriate number of sheep to graze on the land in order to maximize her long-term earnings. The other possible option is for a government body to restrict the amount of grass that can be consumed. However, in order to enforce the restriction, the government would have to monitor the amount of grass consumed by each herder—a costly exercise. An alternative would be for the government to require that herders

pay a tax per head of sheep, which the government would use to hire a guard to monitor whether the herders follow the rules.

The importance of Hardin's argument is its conclusion that people are not able to self-govern common resources. That is why he calls it a tragedy. The fact that Hardin focused on this inevitable tragedy is perhaps related to his use of the term "commons." In fact, in traditional contexts there was no "freedom in a commons"—a commons always had a set of rules associated with its use, and these rules did not necessarily include either of Hardin's two options. Unfortunately, Hardin's judgment has been widely accepted due to its consistency with predictions from traditional economic sciences and increasing numbers of examples of depletion of environmental resources. What this judgment fails to take into account are the many cases of successfully managed commons in which the shared resource is used sustainably. That is, there are many cases where a "tragedy of the commons" has been averted without privatization or state control.

The consequences of this work were significant. Hardin and others did distinguish three types of property rights: communal, private and state. However, they equate communal property with the absence of exclusive and effective rights and thus with an inability to govern the commons. Experience does not bear this definition out: communal property, or common-property governance regimes do provide exclusive and effective rights, which are often used to govern the commons. From Hardin's perspective, which neglected this third governance regime, sustainable use of shared resources without the state or private property was only possible when there was little demand or a low population density.

Garrett Hardin provided a compelling explanation for the emerging environmental movement in the 1960s. There was an increasing awareness of the decline of natural resources due to human activities, including the perceived scarcity of raw material; deforestation; overfishing; as well as increasing levels of water and air pollution, leading to smog and acid rain as well as health problems for human populations.

A few years after the publication of Hardin's article, the first oil crisis took place which led to a rapid increase in oil prices. This shock generated the perception that oil was becoming scarce and that we were overusing our shared resources. Hardin's paper provided a simple analysis and a simple solution. Assuming people make rational decisions, the implications for policy were clear. To avoid overexploitation of resources shared in common it was critical for the state to either 1) establish, monitor, and enforce private property rights or 2) directly regulate the use of the commons either by taxing or directly restricting (e.g., licensing) its use.

Figure 1.3 shows the decline of the stock of predatory species in the world's oceans over a 40–50 year period during the second half of the 20th century (Myers & Worm, 2003). Since the 1968 essay, policies have changed, yet we haven't seen a reversal of the overall trends. The fish stocks in Figure 1.3 still have not started to recover even after the institution of many new fishing policies since the early 1970s. Moreover, we are now beginning to experience new environmental commons problems, like the loss of biodiversity and climate change, despite efforts by nations to draft international treaties to regulate these "global commons."

As we have hinted above, we will show in this book why Hardin's analysis was limited. Although we see resource collapses around the world (tragedies of open access), we also see many success stories of long-lasting governance of shared resources (triumphs of the commons). Open access situations are not always tragedies. Many times common-property management regimes fail, as do private property and state-centric regulatory governance regimes. There are no panaceas. The goal of this book is to illustrate a set of tools that can be used to determine what conditions make overexploitation more likely and what conditions are more likely to lead to the sustainable use of

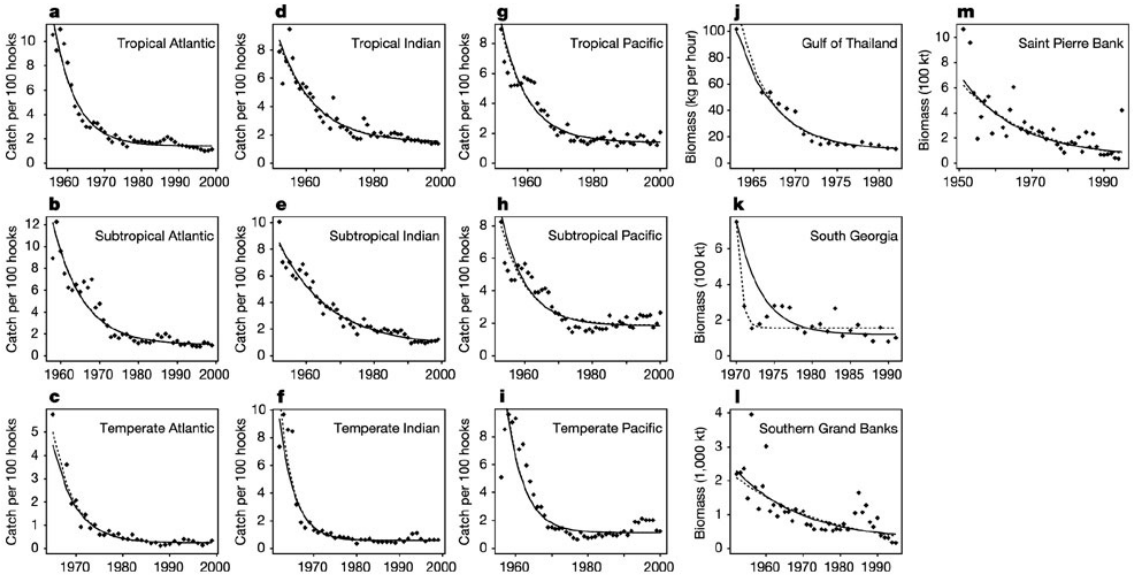


Figure 1.3: Relative biomass estimates from the beginning of industrialized fishing (Myers & Worm, 2003)

shared resources.

1.3 The common pasture of Hardin

As we mentioned above, in his description of the "commons," Garrett Hardin implicitly assumed open access of the pasture. The example Hardin gave was grazing on common land in Medieval Europe. Let's look at the actual situation of the medieval open-field system in Europe, especially in England, in more detail (Figure 1.4).

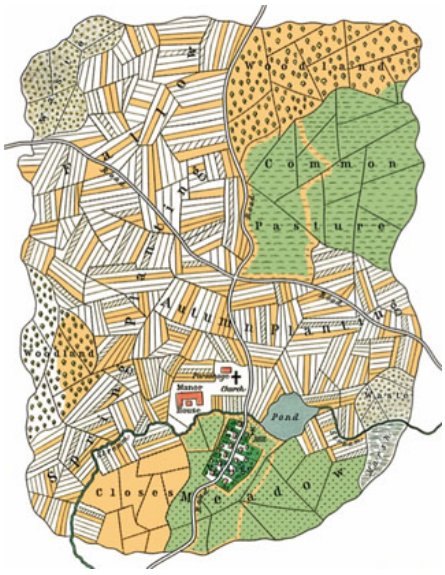


Figure 1.4: Open field system

In the open-field system, peasants had private property rights to the grain they grew on multiple small strips of land that were scattered around a central village. However, during particular seasons, peasants were obligated to throw the land open to all the landowners in a particular village so that they could all graze their sheep on the common land under the supervision of one herdsman. The decision to convert the strips of privately used land into shared land for a period during each year was made by a village council. This enabled people to take advantage of economies-of-scale in grazing (as well as providing manure for their land) and private incentives in grain growing (which lacks important economics of scale and suffers from free-riding when communal groups try to share labor inputs).[1]

The purpose for scattering small strips of land has been debated among scholars, as the benefits

[1] This is an example of a social dilemma, a topic we will discuss in Chapter 4.

of the two scales could be achieved with or without the scattering of the agricultural land. Further, the scattering of land appears to have been an inefficient system, given that a single farmer had to divide his time between multiple, small agricultural strips rather than being able to economize on his own time and focus on one piece of land. Some scholars argue that the need to share risk due to different soil and precipitation patterns may have been a contributing factor. Others argue that by not allowing any one farmer to gain a large amount of contiguous land, the village avoided creating a situation of asymmetric bargaining power. No farmer owned enough land to be able to "hold out" from the commons and graze his own animals on his own land. Nor did an individual have a right to exclude others once the village decided the land should be converted from agriculture to pasture. If all of the farmers had owned sizable chunks of agricultural land in "fee simple" (a form of private ownership in England), rather than the village being responsible for land-allocation decisions, transaction costs would be very high.

If the argument that the commons were managed effectively in the open-field system has some validity, why did the open-field system disappear? And why did it take such a long time for it to disappear across most of Northern Europe? If private property alone was a very efficient solution to the production of food, once a particular location discovered this efficient solution, one would expect to see a change occur rapidly throughout Europe. The explanation might relate to transportation costs. Due to high transportation costs, local communities needed to produce both meat and grain in a small local area for their own consumption. This was only feasible if they could convert agricultural land to a common pasture when the crops had been harvested. When transportation networks improved and communities gained access to markets in grain and meat, there was no longer a need to continue with this complicated adaptation. Communities could specialize in meat or grain. Interestingly, this shift was facilitated by the development of a new "commons," i.e., the shared resource of the public transportation system.

Thus, as we mentioned above, the medieval commons used by Hardin in his metaphor were, in reality, not open access. The commoners had crafted effective norms and rules to govern their shared pasture and to avoid overexploitation. Moreover, there are many implicit rules involved in the use of the commons. For example, a herd of livestock is the private property of the farmers, but the grass they consume does not become private until the animal swallows it. Could farmers directly harvest the grass for their livestock? A farmer who does so will likely get in trouble as there might be informal rules that grass can only be harvested via the livestock.

This simple example of a shared pasture with grazing sheep illustrates how common-property governance typically involves many rules and norms. Often, the intentions of these rules and norms and the way they function are not at all obvious from the casual observation. We will see that there are always many such norms and rules involved in the use of the commons—some obvious, some very subtle.

In summary, at the time Hardin wrote his now-classic article, the work on collective action was rooted in rational choice theory. A key assumption of this theory was that actors made rational (calculated) decisions based on selfish motives (weighing individual costs and benefits). The implications for policy were clear: to avoid overharvesting of shared resources it was critical to establish private property rights or tax the use of the commons. Much work since has shown that this simply isn't the case.

1.4 The tragedy is not inevitable

Since Hardin's essay, an increasing awareness has emerged that tragedy is not the only possible outcome when people share a common resource. There are many examples of long-lasting communities that have maintained their shared resources effectively. Since the 1980s there has been a steady increase in interdisciplinary efforts to debunk the simplistic view of the tragedy of the commons. *Elinor Ostrom* (Figure 1.5) and others showed through comparative analysis of many case studies that communities can self-govern their shared resources.

Elinor Ostrom was a political scientist who developed a theoretical framework to study the ability of communities to overcome the tragedy of the commons. This research earned her the 2009 Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (better known as the Nobel Prize in Economics). Her PhD thesis, which she finished in 1965, focused on the management of shared groundwater resources in Southern California. In her first fifteen years on the political science faculty at Indiana University she studied police forces in U.S. cities, seeking to discover which type of organization led to the most effective policing.

Because she worked on various types of projects related to the governance of shared resources, she started to see commonalities. Since the early 1980s, Ostrom developed a more theoretical understanding of the institutions, rules and norms that communities use to organize themselves. This led her to create the Institutional Analysis and Development (IAD) framework, which is a core framework in this book.

Figure 1.5: Elinor Ostrom

During the mid-1980s Ostrom returned to the study of problems related to the governance of environmental commons. An increasing number of scholars at the time were realizing that reality clashed with the conventional view that the use of a shared resource would end in environmental disaster. Ostrom proved instrumental to this revolution in thinking by leading an effort to compile hundreds of case studies—successes and failures—from the lobster fisheries of Maine to the irrigation systems of Nepal.

The comparative analysis of these case studies allowed her to identify features that were more common in successful cases. In her 1990 book *Governing the Commons*, she identified eight design principles that characterized successful self-governance strategies, including having monitors who are accountable to the users of a resource and cheap mechanisms for conflict resolution. Those principles are discussed in Chapter 7 and have held up to the test of time.

Since the early 1980s, an increasing number of anthropologists, sociologists, political scientists, ecologists, and many other scholars have been documenting examples of resources shared in common that have been managed sustainably for a long time without private property rights or governmental interventions. This led to the development of a community of scholars who came together to create the International Association for the Study of the Commons (www.iasc-commons.org) of which Elinor Ostrom was the first president.

The work coming out of this community has provided an alternative framework to study the use of shared resources, i.e., resources held in common. The material discussed in this book is largely based on this alternative framework which has been widely recognized. Besides a Nobel Prize in Economics (which was seen by Ostrom as a recognition of the whole research community in this

area, not an individual accomplishment), insights derived from this research are increasingly applied to governance and policy issues.

Applications can be found in organizations that manage development projects in developing countries, advance agricultural practices to improve food security, and protect biodiversity. Moreover, the insights on how to sustain the commons are increasingly applied to non-traditional commons such as in the areas of knowledge, culture, education, and health. For example, the communication revolution driven by the internet has generated all kinds of new challenges related to governing the digital commons. Creations consisting of mainly information (movies, books, music) are so easy to copy, that many get distributed without any payment to the owners of the intellectual property rights. Strangers can post improper comments to websites. Emails are sent around in order to gain access to your private information.

Although the framework on which this book is built can be applied to all kinds of commons, we will focus on commons related to sustainability challenges. However, we will use examples from other applications to illustrate some of the challenging concepts. As such, the book is not limited to a specific application but, rather, provides a series of concepts and frameworks that help us better understand the challenges of sustaining the commons and design possible solutions.

1.5 Outline of the book

The book consists of 15 chapters. The first few chapters discuss some basic concepts and frameworks such as **institutions**, **action arenas** and **social dilemmas**. These concepts will provide the key theoretical foundation for analyzing problems related to the commons. In Chapter 2 we define institutions, the rules and norms that structure human interactions. This is a very broad concept but we will see that understanding the rules and the norms related to the use of the commons helps us understand how to sustain them. We will use the general terminology of "institutions" rather than of private property or markets, since those two examples are vague and imprecise definitions of clusters of possible institutional arrangements. The **institutional analysis and development (IAD) framework** that we will discuss in this book provides a more general and accurate way of studying institutions and their performance.

In Chapter 3 we will focus on action arenas, a key component of the IAD framework which connects **participants** to an **action situation**. We can use the concept of action arenas to dissect what are the **incentives**, the possible **actions,** and the **positions** of people who are using the commons. Social dilemmas, discussed in Chapter 4, are action arenas in which two or more persons can benefit collectively from cooperation, but individually from **free riding** or **defecting**. We discuss various commonly studied social dilemmas such as the **prisoner's dilemma**, **public goods** dilemmas and **common-pool resource** dilemmas.

Chapters 5 and 6 discuss various empirical examples the governing the commons related to natural resource use. The examples cover a range of different resources, from water management in Arizona to lobster fisheries in Maine. Using the language and concepts introduced in Chapters 2-4 we will see that we can better understand the challenges people have to overcome in order to sustain their commons. We will also see some remarkable examples of institutions that facilitate success. The eight **design principles** defined by Elinor Ostrom, based on the analysis of many case studies, are discussed in Chapter 7.

Finding regularities in case studies is not sufficient to understand the mechanisms that enable communities to successfully sustain their commons and those that cause them to fail. Social scientists **use controlled experiments** to test hypotheses about such mechanism. These experiments help us

better understand how humans make decisions in various types of action arenas. Moreover, we can replicate the findings over and over again to build our confidence that we can generalize the results. Chapter 8 discusses general findings from social dilemma experiments, and Chapter 9 focuses specifically on public goods and common pool resources. We see that humans do not always act as the **selfish rational actor** model would predict. This calls into question a basic assumption underlying the argument of Garrett Hardin. In contrast we find that humans have **other-regarding preferences** and cooperate if they expect others will cooperate too.

In studying many case studies and experiments, we find many types of rules. Chapter 10 provides a rule **classification** scheme based on linking the rules to the different attributes of the action arena. So far we have loosely talked about rules and norms, but in Chapter 11 we will be more precise and introduce an approach to dissect and classify rules and norms from their **linguistic statements**.

Chapters 12, 13 and 14 will introduce concepts from system science and apply them to collective action and problems of the commons. We will discuss in Chapter 12 **feedback** loops (positive and negative), **resilience** and **tipping points**. Chapter 13 introduces an extension of the IAD framework by introducing resilience and **infrastructure** in **coupled infrastructure systems**. In Chapter 14 the discussion is extended to **larger scale problems** such as climate change. Chapter 15 closes the book with a discussion on the main lessons learned and which **challenges** scholars in this field are now addressing.

1.6 Critical reflections

Commons are natural and cultural resources that are shared by many people. People can affect the commons by harvesting from them and making contributions to their construction and/or preservation. The core question this book attempts to address is how we can sustain the commons. **Garret Hardin** introduced the notion of the **tragedy of the commons** which can occur if people share a resource. The opportunistic behavior of individuals can lead to overharvesting of the shared resource. The only way to avoid the tragedy, according to Hardin, is to establish private property rights or tax the use of the commons. **Elinor Ostrom** and her colleagues show from case study analysis that overharvesting is not inevitable and that successful **self-governance of the commons** is possible.

1.7 Make yourself think

1. Come up with commons you experience yourself.
2. Are these commons functioning well?
3. Did your grandparents use different commons than you do?
4. Now that you know about the commons, can you relate the idea of the commons to the budget discussions in Washington D.C.?

1.8 References

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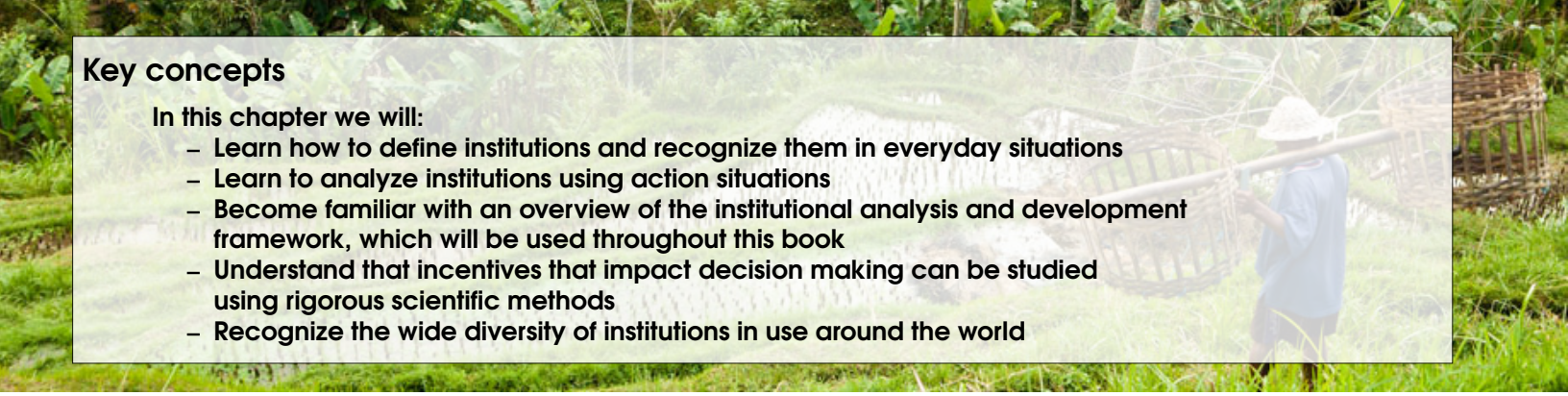


Key concepts

In this chapter we will:

- **Learn how to define institutions and recognize them in everyday situations**
- **Learn to analyze institutions using action situations**
- **Become familiar with an overview of the institutional analysis and development framework, which will be used throughout this book**
- **Understand that incentives that impact decision making can be studied using rigorous scientific methods**
- **Recognize the wide diversity of institutions in use around the world**

2 — Defining Institutions

Cow Jail

In the hills of Nepal there are some remarkable ways people manage irrigation systems. When Elinor Ostrom performed field work in this area in the 1990s she noticed an enclosed field with a domesticated cow in the center of a village. Her Nepali colleagues explained that this was a kind of "cow jail." If three adult members of the local irrigation system agreed that a village member had not followed the irrigation rules, they could confiscate a cow from the offender. These rules were related to how much water a farmer was allowed to take from the irrigation system and how much labor was to be contributed to maintaining the canals of the irrigation system. In these small communities everybody would recognize the cow. Thus, if your cow is seen grazing in the center of the village, everybody would know that you were cheating the community by either taking more than your fair share of water or by not contributing sufficient labor to maintaining the irrigation infrastructure. Moreover, people in the community could milk the cow—a sort of payment for the water or labor that they lost to the guilty farmer. Once the farmer had paid a fee (on top of the milk he lost from his jailed cow) the cow would be released and returned to the owner. Needless to say, most members of the irrigation system prefer to follow the rules rather than being embarrassed in this way.

The use of cow jails to get people to comply with the rules looks very exotic. Cow jails are unlikely to work in the U.S.. However, the principle of shaming as punishment is also used in the U.S. For example, many states publish the names of families and firms who are delinquent on their taxes. The top 250 tax delinquents in the State of California can be found at https://www.ftb.ca.gov/aboutFTB/Delinquent_Taxpayers.shtml. This list might be less controversial than a cow in the middle of a village, but being on that list will affect your reputation. As a result, such families and companies may correct the situation and pay their taxes in order to get their name off the list (i.e., get their "cow out of jail") and gain back their reputation.

2.1 Overview

The example of the cow jail illustrates that there are very diverse ways to induce people to contribute to the commons. In the case of the cow jail the "commons" consists of the shared infrastructure made up of canals and water diversion mechanisms and the common-pool resource of irrigation water (we will define these different types of goods that appear in the "commons" more precisely in Chapter 4). When farmers do not contribute to the maintenance of the shared infrastructure, they will experience some shaming. The solution in villages in Nepal cannot be blindly copied and be successful in other places. Most families in urban areas have no cows, a fact that will limit the applicability of this solution. We will see that there are many different possible mechanisms that groups use to solve problems related to sustaining the commons. These different mechanisms, however, all rely on the

same principles. Therefore, in this book, we will try to understand how people solve these problems by studying the basic principles contained in the institutions they use.

Broadly defined, **institutions** are the *prescriptions that humans use to organize all forms of repetitive and structured interactions*. This includes prescriptions used in households, schools, hospitals, companies, courts of law, etc. These prescriptions can function at different scales, from households to international treaties. These prescriptions can be one of two broad types: rules or norms. Because rules and norms are essentially human constructs, agreed-upon or recognized by a group of people, they are not immutable. That is, individuals can make choices whether or not to follow the rules or norms. Importantly, their choices and actions have consequences for themselves and for others.

In the following chapters we will see that rules and norms are everywhere and define —sometimes literally, sometimes indirectly—how we live our lives. For example, rules and norms can affect who we marry, which schools we go to, which countries we enter, where we may sit on a bus, where we may park, who leads a discussion in a group, etc. Where do these rules and norms come from, and why do they differ in different countries and contexts? In this book, we are especially interested in answering this question for different types of commons.

We will see that all of us can play a big role in defining rules and norms if we take the initiative to do so. Crafting rules and norms is not something that is undertaken exclusively by those in business suits in Washington, D.C. We ourselves create rules and norms too. For example, when you undertake a group project during a course, you will have to rely on some rules and norms. Some rules might come from the syllabus while others are created by you and the members of your group during your meetings.

In more abstract terms, the rules (or the absence of rules) in a particular situation affect who gets what benefits, who bares what costs, who is allowed to participate, and who gets what information. Further, the rules affecting one situation are themselves crafted by individuals interacting at higher levels. For example, the rules we use when playing basketball at lunch time were themselves crafted by officials who have to follow such rules and norms to structure their deliberations and decisions.

This chapter provides a brief overview of the framework we will use in this book to study institutions. In the following sections we will discuss these core questions:

- Why are there so many different types of institutions?
- How do we analyze institutions?
- What is the appropriate unit of analysis for studying institutions in general, and the commons in particular?
- How do we use one choice of an analytical unit, the action arena, to study institutions?
- What are the core components of an action arena?

2.2 Institutional diversity

During a typical day we experience many situations in which we interact with others in a structured way where rules and norms may apply. This can be at work, in the classroom, on the sports field, in the supermarket, during commuting, when we bring our kids to daycare, when we watch a movie online, when we go to church, when we eat at the dinner table, etc. In all these different settings different types of norms and rules hold. At work you may have a formal contract regarding the duties that are expected from you and the compensation you are given for undertaking those duties. At the dinner table you may adopt some manners (which are the equivalent of norms) taught to you by your parents. In traffic you follow the norms and rules of the road. For example, a rule of the road

is a speed limit. A norm is you don't cut other drivers off when changing lanes. Can you tell the difference between a rule and a norm just based on these examples? Finally, we interact with many strangers every day whom we expect to follow the same rules.

When you start realizing the number of rules and norms we implicitly deal with on a daily basis, it might become overwhelming. But most of us are easily able to participate in all these diverse sets of situations without thinking too much about the rules and norms that structure them or specific decisions we make in those situations. Several scholars have explored the question of what enables us to do this. Not only are we faced with many different situations each day, the situations we can experience change over the generations. It is likely that today we experience more different types of situations at different levels of social organization as compared to previous generations. People living in a small village in Europe in 1200 AD were not thinking about the implications that political developments in China might have on their lives. We now expect to communicate with our relatives or be able to check on the latest news wherever we are in the world. Our meals are not restricted by the seasonal availability of foods produced by local farmers. We transport the ingredients for our meals from all over the world (e.g., tropical fruits and vegetables in the winter in New England) at considerable environmental costs. Such changes are not just caused by technological developments, but also through changes in institutions. To make sure fruits and vegetables are transported reliably from location A to B, we have to create institutions to structure repetitive interactions between all the individuals involved. Without institutions, the transaction costs for exchanges between farmers, transporters, and retailers would make long distance transport of food extremely costly.

Figure 2.1: Differences in technology affect the type of institutions that are used.

It is obvious to us what to do when we are shopping in a supermarket. We take the goods we prefer from the shelves. We then "arrange a meeting with the cashier," which is made easy by check out lines and the norms for standing in lines (standing in lines is not a norm everywhere). The cashier knows we wish to have a meeting by virtue of the fact that we are standing in line. We then engage in an exchange with the cashier. What exactly do we exchange with the cashier? Do we exchange food? No—the cashier does not own the food. We exchange information. We may give a piece of plastic with information on it (a credit card) to the cashier or we may use cash—which is also a form of information about value and obligation. But this strategy does not work everywhere. When we are shopping in an open bazaar in Asia or Africa, we may bargain over the price of the fruit that is left on the stand at the end of the day. Such bargaining to get a lower price is also happening for other goods in a bazaar. In fact, not bargaining (i.e., not adopting a local norm) for a lower price would be a clear indication that you were a stranger and that you do not know what to do in this situation. This may drastically affect the price of the good. Finally, in this case, the seller may actually own the fruit and thus will be exchanging goods with you. What will you be exchanging for the goods? Probably not a number and an expiration date on a piece of plastic. Can you use U.S. dollars, say in Africa? Maybe, maybe not. These examples illustrate that there are many (subtle) changes from one situation to another even though many variables are the same. These subtle changes can have major consequences for the interactions between people.

The types of institutional and cultural factors we have been discussing affect our expectations

regarding the behavior of others and their expectations regarding our behavior. For example, once we learn the technical skills associated with driving a car, driving in Phoenix (Arizona) or Bloomington (Indiana)—where everyone drives fast but generally follows traffic rules—is quite a different experience from driving in Rome, Rio de Janeiro, and even in Washington, D.C., where drivers appear to be playing a game of chicken with one another at intersections rather than following traffic rules. Driving in India can seem like a life-threatening experience. Nobody seems to follow traffic rules but there are clear norms such as "the cows are free to go wherever they want, including highways," or "honk when you drive behind somebody so they know," and "expect the unexpected." When playing racquetball with a colleague, it is usually okay to be aggressive to try to win by using all of one's skills. On the other hand, when teaching a young family member how to play racquetball, the challenge is how to help them have fun while they learn a new skill. Being too aggressive in this setting—or in many other seemingly competitive situations—may be counterproductive. A "well-adjusted and productive" adult adjusts their expectations and ways of interacting with others to "fit" a wide range of different situations. Such adjustments are often second nature.

Figure 2.2: If you want to buy a ticket for a concert and you see people standing in line, you would automatically join the back of the line. What do you suppose would happen if you bypassed the line to buy your tickets? Although there might not be any formal signs that say you need to wait for your turn, it is generally assumed you understand you have to do this.

Although we may not explicitly realize it, we have a lot of implicit knowledge of expected dos and don'ts in a variety of situations. Frequently, we are not even conscious of all of the rules, norms, and strategies we follow. Nor have the social sciences developed adequate tools to help us translate our implicit knowledge into a consistently explicit theory of human behavior. In most university courses students learn the language of a particular discipline, from anthropology to economics, from psychology to political science, etc. This disciplinary narrowing of language may hinder our understanding of how to analyze the diverse sets of situations we encounter is social life. The framework we discuss in this book may provide a common language to study these different situations.

2.3 How to analyze institutions?

If the situations in which people experience different norms and rules are so diverse, how can we study them? How can we make sense out of such complexity? Given that there is such a large variety of regularized social interactions in markets, hierarchies, families, legislatures, elections, and other situations, is it even possible to find a common terminology to study them? If so, what framework could we use to analyze these different situ-

The Genes of Institutions

There are millions of different species on our planet that interact in complex ways at different spatial and temporal scales. How does one study such complexity? One of the breakthroughs in biology is the concept of genes and the discovery of DNA, the building blocks of the diversity of life forms on Earth.

Can we develop an equivalent set of concepts for building blocks that create institutions? This will help in the study of the large institutional diversity we observe around us. In this book we will discuss the initial steps of a genomics of institutions that enable us to decode and compare institutions.

ations across different cultures? Can we learn from one type of institutional arrangement and apply the lessons to another one?

Can we identify attributes of the context in which people carry out their repeated interactions in order to find communalities that distinguish success stories from failures? If we are successful with this, we may be able to explain behavior in a diversity of situations varying from markets and universities to religious groups and urban governance. This analysis of interactions among people may take place at a range of levels from the local to the global, and we may analyze whether processes occurring at the local level may explain some of the challenges at the global level.

These are all very ambitious goals. However as you will see from the material in this book and associated coursework, the framework that we will discuss will help to provide us with a much better understanding of key features that appear throughout a diverse set of situations. The framework is an outcome of many studies conducted at the Vincent and Elinor Ostrom Workshop of Political Theory and Policy Analysis at Indiana University, which was created in 1973 by Vincent and Elinor Ostrom (Figure 2.3). Many of their colleagues all over the world have contributed to this framework by testing it on diverse sets of problems. In teaching this framework over the years in undergraduate classes at Arizona State University, we have developed this book to communicate the rather complex framework to a broader audience.

Figure 2.3: Elinor and Vincent Ostrom

In the rest of this chapter we will provide a brief overview of the basics of the framework. The framework is called the Institutional Analysis and Development (IAD) framework. One of the aspects of social systems that makes the IAD framework complex is the existence of different types of regularized social behaviors that occur at multiple levels of organization. There is no simple theory that predicts everything, and therefore we need to understand what kind of behavior is to be expected in each type of context.

2.4 Action arenas and institutional analysis

An action arena occurs whenever individuals interact, exchange goods, or solve problems. Some examples are teaching a class, playing a baseball game, having dinner.

When two people exchange a product on eBay, they are in an **action arena**. This is an example of the focal level of analysis we use throughout this book. In an action arena, participants, rules and norms, and attributes of the physical world come together. The latter two elements, the rules and norms and the physical world are said to define an **action situation**. Action situations remain stable over time relative to the participants who may take part. For example, the eBay action situation does not change over the course of a day during which millions of participants can enter the action situation and generate an action arena. As participants interact in the action arena, they are affected by exogenous variables and produce outcomes that, in turn, affect the participants and the action situation. Action situations exist in homes, neighborhoods, regional councils, national congress, community forests, city parks, international assemblies, and in firms and markets as well as in the **interactions** among all of these situations. The simplest and most aggregated way of representing any of these arenas when they are the focal level of analysis is shown in Figure 2.4, where exogenous variables affect the structure of an action arena, generating

interactions that produce outcomes. **Evaluative criteria** are used to judge the performance of the system by examining the patterns of interactions and outcomes.

Let's discuss some examples. Consider two participants: John and Alice. When John and Alice play a game of chess, the action situation is composed of (a) the physical game of chess including the board with 64 squares and the pieces: 8 black and 8 white pawns, 2 black and 2 white rooks, 2 black and 2 white knights, 2 black and 2 white bishops, 1 white and 1 black queen and 1 white and 1 black king and (b) the rules of chess—how each piece can be moved, how pieces interact, and what constitutes a victory. When John and Alice sit down at the chessboard to play, this forms an action arena. The interactions between the players may lead to either John or Alice winning the game or a tie. Hence the outcome is whether the game is won by one of them or whether it was a tie. The same persons may also be in an action arena involving money lending. In this action arena, the action situation may be less structured than the chess game. Consider the action arena in which Alice lends money to John. Suppose Alice and John are good friends and the amount of money is small. Alice gives the money to John who agrees to return the money at some specified date (often rather vague in such situations). In this case, the action situation is simple: it is defined by the shared norms of informal money lending in Alice's and John's culture. Suppose, on the other hand, that this exchange is performed in a formal way. Another participant enters the action arena, a notary public, who formulates a contract that is signed by Alice and John. In this case, the action situation is slightly more complex as it involves a formal contract legitimized by the notary's presence and the signatures of Alice and John. Now the formal rules of contract law, the testimony of a third party recognized by the state (notary) who will testify to the identity of the signatories of a contract, and an entity that will archive the contract form the action situation. The outcome of this transaction is that John receives the money and pays it back according to the conditions as stated in the contract. A third possible action arena would be an election. Alice and John are both candidates for president of the student association. Within the action arena participants include all the students of the association who are allowed to vote for one of the candidates. The interactions include debates, a campaign, and finally the election day in which a winner is decided. The evaluation criteria stipulates that the winner is determined based on which candidate has a simple majority (i.e., more than 50%) of the votes. In the last example, Alice and John are neighbors who have a conflict about the barking of Alice's dog. The action situation is a conflict. Within the action arena we have Alice, the dog, John, and the local authorities whom John calls to intervene. Alice and John may both hire lawyers to represent themselves when the action situation (conflict) is played out in court. The interactions include the daily occurrences of the dog barking, the initial friendly requests of John to silence the dog, and the escalation of the conflict into a court case. There are various possible outcomes: either John or Alice moves out of the neighborhood, the dog gets training to stop barking, the dog is sold, John gets a financial compensation for the inconvenience, etc. Each outcome is evaluated differently by each of the participants, including the lawyers. For example, if John's lawyer gets a certain percentage of the financial compensation, she may focus on winning a case to get that financial compensation, although this may lead to long-term bad relations between Alice and John.

Outcomes feedback into the participants in the action arena (the dashed arrow from outcomes to the action arena in Figure 2.4). For example, the fact that a player loses a chess game affects her next decision regarding the action situation of playing chess (play another game or not). The dog continuing to bark after one interaction (John asks Alice to quiet the dog) will undoubtedly affect John's next decision. This changed view by one or several participants may induce the action situation to transform over time as well. Over time, outcomes may also slowly affect some of the exogenous variables. For example, decisions people make regarding energy use creates outcomes

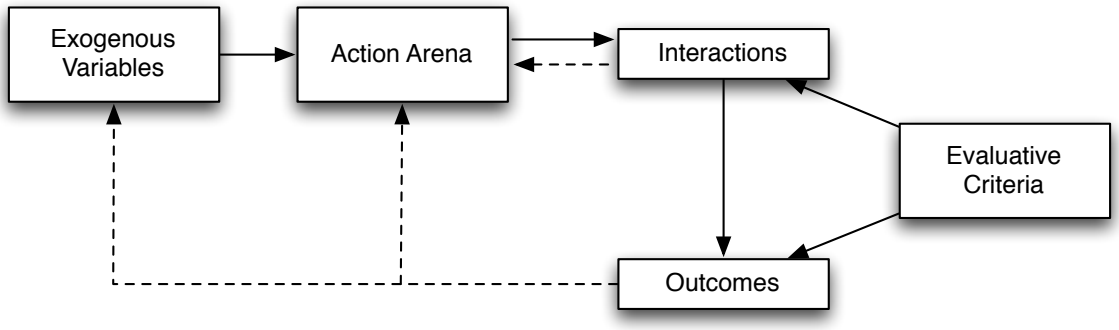


Figure 2.4: The focal level of analysis—an action arena (adapted from Ostrom, 2005).

including emissions of CO_2 which in the long term affect the climate system. In a world with a changed climate the costs and benefits of various human activities are affected, which will affect action arenas. In undertaking an analysis, however, one treats the exogenous variables as fixed—at least for the purpose of the analysis.

When the interactions yielding outcomes are productive for those involved, the participants may increase their commitment to maintaining the structure of the situation as it is, so as to continue to experience positive outcomes. For example, wealthy people who may have benefited from low taxes in the past may support tax cuts that the Bush administration introduced. However, if participants view interactions as unfair or otherwise inappropriate, they may change their strategies even when they are receiving positive outcomes from the situation. For example, a group of millionaires requested that President Obama raise taxes for wealthy people (http://politicalticker.blogs.cnn.com/2011/11/16/millionaires-ask-congress-to-raise-their-taxes/).

When current outcomes are perceived by those involved (or others) as less desirable than other outcomes that might be obtained, some participants will raise questions about particular action situations and attempt to change them. But rather than trying to change the structure of those action situations directly, they may move to a different level and attempt to change the exogenous variables. The Occupy Wallstreet movement of 2011 was a protest against the perceived unfairness in society due to a culture of greed by bankers and other participants who control the financial system. The protesters requested a change of the financial system (the exogenous variable) in order to move toward a more equitable society in which they may also succeed (a different outcome) (http://www.huffingtonpost.com/2011/11/08/wall-street-bonuses_n_1081902.html). But they didn't try to change the banking system directly. They tried to affect the exogenous variables, for example, the perception of the general public toward the actions of banks.

Figure 2.4 is the simplest schematic representation of an action arena. As you see from the example, there are many important layers to each action arena. We unpack this simple representation in Figure 2.5 in order to make these layers more apparent. An action arena refers to the social space where participants with diverse preferences interact, exchange goods and services, play a game, solve problems, have an argument, receive and deliver health care, etc. We make a distinction between an action situation and an action arena to emphasize that the same participants can fill different roles in different action arenas as we saw with John and Alice. The action situation refers to the positions, actions, outcomes, information and control that provide the structure by which participants interact. Thus the action situation provides the institutional context with which the participants in an action arena are confronted. In Chapter 3, we will zoom in and unpack the action arena. Let's look at a

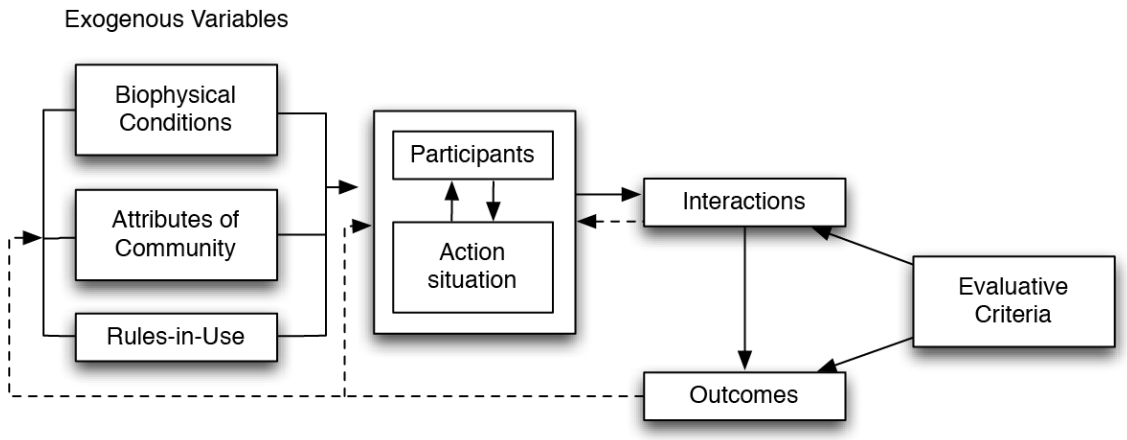


Figure 2.5: A framework for institutional analysis (adapted from Ostrom, 2005).

broader overview of the IAD conceptual map.

Let's apply the framework to a concrete example, namely the course you are taking for which you are reading this book (Figure 2.5). The action situation is defined by the general rules about taking a course at your university (grades, credits, conduct) further specified by the syllabus for this particular course and the characteristics of the space in which the participants meet. Taking this course (along with all the other students) then constitutes an action arena. In the action arena there are a number of different participants, namely the students, the professor and the teaching assistant. The participants interact via lectures, taking exams and writing essays. The syllabus of the course specifies what is needed to receive a good grade in the course. It specifies the weight of the different types of interactions, from participation in class, giving a talk, writing an essay and taking an exam. For each of these activities there are more detailed evaluation criteria on how to receive a good exam grade or writing the essay. The final outcome of the course is a grade.

The exogenous variables in which these interactions take place are the facilities of the university campus (the quality of the classrooms, computer commons, etc.), the attributes of the students (what criteria is required to be admitted to the university, quality of other courses, etc.), and the university regulations. These are specific examples of the general categories of exogenous variables in Figure 2.5: The biophysical conditions, the attributes of the community, and the rules in use, respectively.

Although the final grade is mentioned here as the outcome of the course, this can be debated. If this were truly the only outcome we cared about, the participants could agree (e.g., all vote to give each other an A) that the students could all get an A without putting in the effort of taking the course. Obviously, this is not the purpose of a course and is a violation of university regulations. Although the focus of many participants in the action situation might be on the grade, there are other outcomes that we may include. Does the course material lead to new insights and useful experiences for the students? Do the students comprehend the material and can the students apply this to other topics or problems they may encounter in life? Is the atmosphere in the classroom pleasant and productive? These kinds of outcomes are more difficult and costly to quantify, but are nonetheless very important. However, the difficulty with measuring such outcomes might be a reason that officials may choose to focus on grades to measure course outcomes.

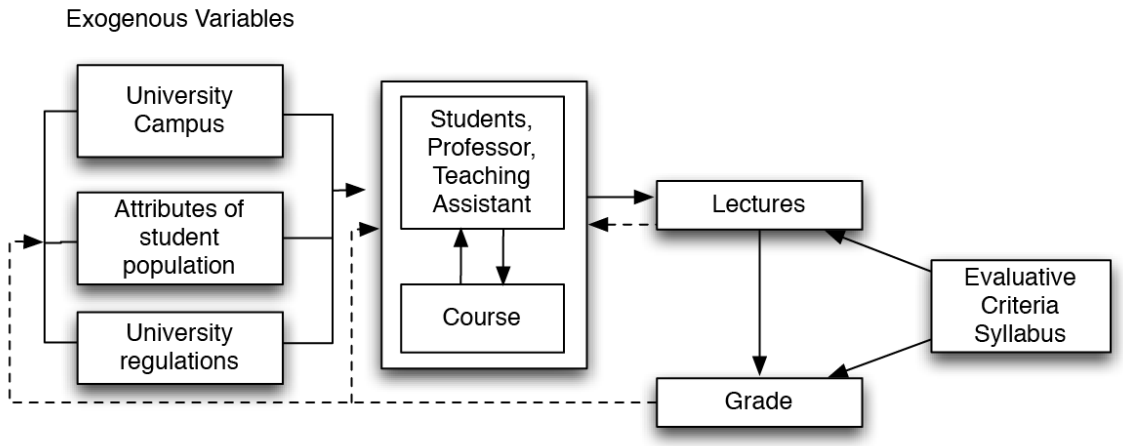


Figure 2.6: Framework applied to taking a course.

2.5 Context of the action arena

The action arena does not occur in a vacuum. Participants are interacting in an action situation which is affected by a broader context. As mentioned above, this broader context is defined by three clusters: (1) the *rules* used by participants to order their relationships, (2) the *biophysical* world that are acted upon in these arenas, and (3) the structure of the more general *community* within which any particular arena is placed.

Different scholarly disciplines focus on different clusters. Anthropologists and sociologists may focus more on the role of the community and culture while economists focus more on how rules affect the incentives of the participants. Environmental scientists may focus more on the biophysical attributes of the action arena. In this book we focus on the rules, but take into account the role of the community and the biophysical environment.

Rules

Many of the readers of this book are used to an open and democratic governance system where there are many ways in which rules are created. Under these conditions, it is not illegal or improper for individuals to self-organize and craft their own rules for many activities. This may be in stark contrast to more dictatorial states in the world. At work, in a family, or in a community organization there are many ways we experience the crafting of rules to improve the outcomes we can expect in the future. Some of these rules are written down on paper, others are verbal and may be confirmed by a handshake.

In our analysis of case studies in this book, we make a distinction between rules-on-paper (*de jure*) and rules-in-use (*de facto*). It is not uncommon that in practice, somewhat different rules are used at the work floor, in the classroom, or on the sports field than those officially written down on paper. For example, a referee in a soccer match may not stop the game for each possible rule infraction, but judge whether the infraction is severe enough to stop the flow of the game and enforce penalties.

Human behavior, including the tendency of humans to comply with rules, is not as predictable as biological or physical phenomena. Humans are reflexive and have opinions and moral values.

They may not necessarily obey instructions from others. All rules are formulated in human language. As such, rules might not always be crisp and clear, and there is a potential for misunderstanding that typify any language-based phenomenon. Words are always simpler than the phenomenon to which they refer. In many office jobs, for example, the rules require an employee to work a specified number of hours per week. How accurately do we need to specify what the employee will be doing? If the employee is physically at her desk for the required number of hours, is daydreaming about a future vacation or preparing a grocery list for a shopping trip on the way home within the rules? Written rules are always incomplete and therefore the very act of interpreting the rules may lead to different outcomes. Monitoring rule compliance is a challenging activity if rules are not always clear and fully understood. Thus, when we study an action arena, we will look not only at the official rules on paper, but also the rules in use. Misinterpretations may lead to differences between the two. For good performance of institutional arrangements, it is important that the rules are mutually understood.

The effectiveness of a set of rules depends on the shared meaning assigned to words used to formulate them. If no shared meaning exists when a rule is formulated, confusion will exist about what actions are required, permitted, or forbidden. The effectiveness of rules is also dependent upon enforcement. If rules are perfectly enforced then rules simply say what individuals, must, must not, or may do. Participants in an action arena always have the option to break rules, but there is a risk of being caught and penalized. Has the reader ever driven faster than the official speed limit? If the risk is low, rule breaking might be common. Further, because of the feedbacks in action arenas, the likelihood of rule breaking can grow over time. If one person cheated without being caught, others may follow and the level of cheating will increase. This will increase the detection of cheating behavior and more rigorous rule enforcement might be implemented. If the risk of exposure and sanctioning is high, participants can expect that others will make choices from within the set of permitted and required actions.

One of the main benefits that accrue to participants when the majority of people follow the rules is the increased predictability of interactions. Virtually all drivers in the U.S. use the right side of the road to drive almost all the time. If such a rule were not obeyed frequently, imagine how difficult it would be to drive and how ineffective it would be to use the road. Knowing what to expect in interactions with others vastly improves the performance of many social systems.

Biophysical conditions

As we will see throughout the book, the rules affect all the different aspects of the action arena. The biophysical world also has an important impact on the action arena. What actions are physically possible, what outcomes can be produced, how actions are linked to outcomes, and what actors can observe are all strongly affected by the environment around any given action situation. For example, water can't run up hill. Once you say something, you can't retract it. The same set of rules may yield entirely different types of action arenas depending upon the context. For example in New York city there is regulation that residents of buildings are responsible for removing the snow on sidewalks in front of those buildings within four hours after the snow ceased to fall. Why does Phoenix not have such a regulation? We will discuss many case studies in different application domains in this book that will help recognize how context affects decision making and the effectiveness of rule configurations.

Attributes of the community

A third set of variables that affects the structure of an action arena relate to the attributes of the community of which the participants are members. Examples of attributes that might be important are the shared values within the community, the common understanding and mental models that the community members hold about the world in which they live, the heterogeneity of positions within the community such as class and caste systems, the size of the community, and the distribution of basic assets within of the community.

The term *culture* is frequently applied to the values shared within a community. Culture affects the mental models and understanding that participants in an action arena may share. Differences in mental models affect the capacity of groups to solve problems. For example, when all participants share a common set of values and interact with one another frequently, it is more likely that the participants will be able to craft adequate rules and norms for an action arena. If the participants have different mental models, come from different cultures, speak different languages, have different religions, it will become much harder to craft effective institutional arrangements.

2.6 Critical reflections

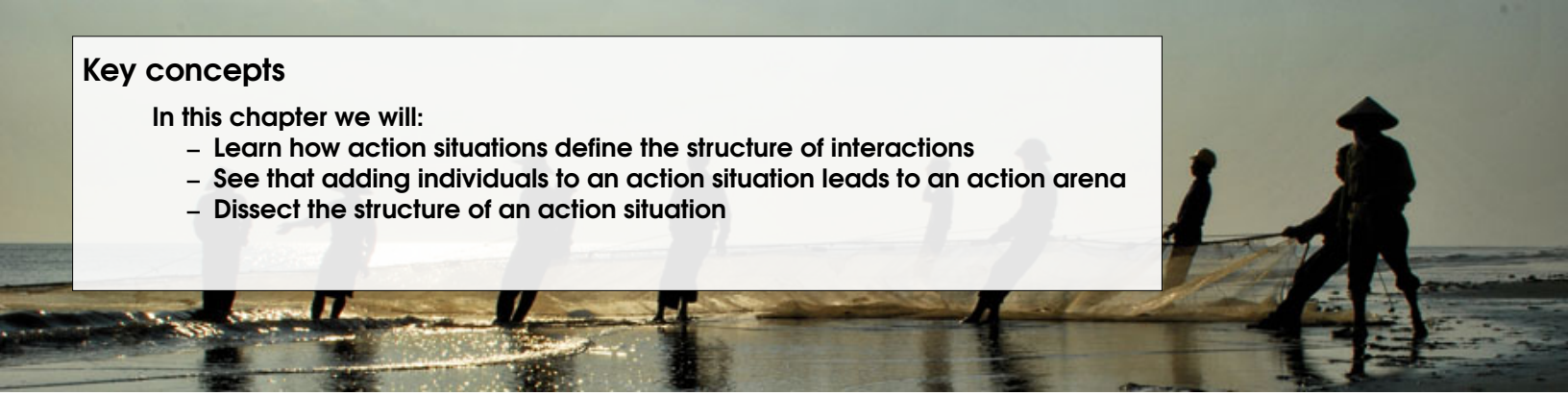
Institutions are rules and norms that structure human interactions. They are complex and difficult to study. The Institutional Analysis and Development (IAD) framework helps us organize our thoughts and direct our questions. The focal element of the IAD framework is the **action arena** in which **participants** interact in an **action situation**. These **interactions** lead to **outcomes** which affect decisions made in the next iteration. The interactions are affected by the social and biophysical context in which the action situation takes place.

2.7 Make yourself think

1. Come up with institutions you deal with every day, some you don't like and some that you do like.
2. Do you think banks should be regulated in their lending practices? What are the key elements necessary to address this question?
3. What is the most important outcome for you in taking this class?
4. What can explain the fact that people solve problems differently in India as compared to the U.S.?

2.8 References

Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.



Key concepts

In this chapter we will:

- **Learn how action situations define the structure of interactions**
- **See that adding individuals to an action situation leads to an action arena**
- **Dissect the structure of an action situation**

3 — Action Arenas and Action Situations

Garbage and Recycling

What do you do with your waste? In most cities there are rules and regulations that outline the specific roles and responsibilities of the various people involved in waste management. Are you a single family, live in a residential community, or a business? Do you have regular waste, recyclable material, compostable material, or even construction debris? When can you put your waste outside, and where? How much does it cost? In some cities you need to buy specific waste bags so that you can be charged for the correct amount of waste that you put at the curbside. In other cities you pay a flat monthly fee. If you use containers, can you just dispose of your waste directly, or does it have to be in garbage bags? Who is responsible for cleaning and maintaning those containers?

As you can see there are many different obligations and roles for the different participants involved in waste management. As a resident you are responsible to sort your waste and provide it at the curbside at the right time and in the right format. The local government has organized the collection of your garbage and may not collect it if it is not provided in the proper format. If you put hazardous waste in your garbage container and somebody gets hurt after you put it at the curbside, who is responsible? Can you put your garbage bags in your neighbor's container? If you put all your recyclable items in the recycling container, who is responsible for the proper recycling of that waste?

Check out the rules and regulations related to garbage collection in your city and think about your responsibilities and the responsibilities of others. How is the garbage collection organized differently in the slums of New Delhi, India versus Portland, Oregon?

Figure 3.1: Garbage collection is organized differently in different cities.

3.1 Action arenas

Whenever two or more individuals are faced with a set of potential actions that jointly produce outcomes, such as garbage removal, these individuals can be said to be "in" an **action situation**. Within an action situation a participant occupies a certain position. The same participants can interact in another action situation where they occupy different positions.

An **action arena** combines the action situation, which focuses on the rules and norms, with the participants who bring with them their individual preferences, skills and mental models. The need to distinguish between action arenas and action situations is a result of the fact that when different participants occupy positions in the same action situation, this may lead to very different outcomes. Put simply, the action situation remains the same for a given period, but a new action arena is generated every time a new set of participants enters the action situation. For example, an action situation might be the market place on eBay. The same product offered by different sellers might not lead to the same price since it depends on the preferences and actions of the different participants who enter the action situation and generate a new action arena. Other examples of action situations include resource users who can extract resource units (such as fish, water, or timber) from a shared resource, politicians in congress crafting new laws, and schools with educators and students.

Likewise, the same participants can have very different types of interactions in different action situations. This could be the result of the simple fact that the participants in different action situations occupy different positions. This could also be due to different rules on the information available in different action situations. A boss and his employee in one action situation might become two squash players in another arena. The boss and employee interact very differently in terms of their power relationship—they leave their professional relationship at the squash court door.

The structure of all action situations can be described and analyzed by using a common set of variables. These are: (1) the set of participants, (2) the positions to be filled by participants, (3) the potential outcomes, (4) the set of allowable actions and the function that maps actions into realized outcomes, (5) the control that an individual has in regard to this function, (6) the information available to participants about actions, outcomes, and the linkages between them, and (7) the costs and benefits—which serve as incentives and deterrents—assigned to actions and outcomes. The internal structure of an action situation can be represented as shown in Figure 3.2. In addition to the internal structure, whether a situation will occur once, a known and finite number of times, or indefinitely, affects the strategies individuals adopt. And again, with the same action situation but different individuals participating, we have a different action arena.

Within a college course, participants have different positions for which different actions are assigned. Students have different responsibilities compared to the professor and teaching assistant. For example, a professor has information regarding the scores of all the students and the authority to give the grades. Students do not have full information about the scores of individual students in the classroom. They may, however, have aggregate information about the all the student scores (i.e., the average). A teaching assistant can grade essays based upon an agreed upon evaluation criteria, but it is the responsibility of the professor to give the grades. Some of the costs and benefits for a professor include the amount of time spent in preparing the class content and lectures and grading and the wage she receives for doing so. The consequences of different allocations of time invested can be seen in the grades the students receive and the evaluations the professor receives. Also the student has to balance the investments of time in taking the course and other activities and this choice will be materialized in the grade received.

An individual can take a class one year (be in the position of student), and become a teaching

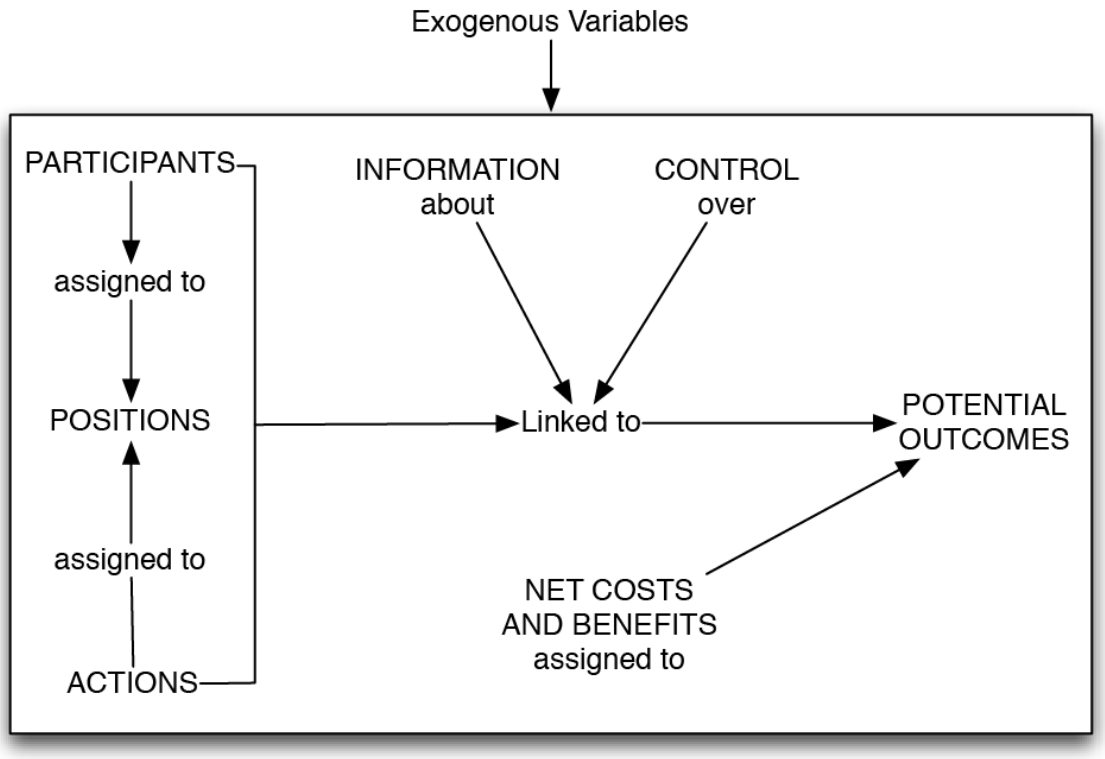


Figure 3.2: The internal structure of an action situation (adapted from Ostrom, 2005).

assistant the next year. That is, the same participant can occupy many different positions. The student could attend a course in the morning as a student, then act as a teaching assistant for a different course in the afternoon. In the morning course, the student has no information about other students' grades. In the afternoon course, she will have more information about the individual students, but now also bears more responsibility for the performance of the students in the class.

The number of *participants* and *positions* in an action situation may vary, but there must be at least two participants in an action situation. Participants need to be able to make choices about the *actions* they take. The collection of available actions represents the spectrum of possibilities by which participants can produce particular *outcomes* in that situation. *Information* about the situation may vary, but all participants must have access to some common information about the situation otherwise we cannot say that the participants are *in* the same situation. The *costs and benefits* assigned to actions and outcomes create incentives for the different possible actions. How these affect the choice of participants depends on the preferences, resources and skills participants have. Who has power? Not all participants may have the same level of *control*, allowing some to have substantial power over others and the relative benefits they can achieve.

Figure 3.3: A poor man polishing the shoes of a wealthy man.

There is inequality in wealth between countries and within countries. There are differences in information access and access to decision makers between the haves and the have-nots. Poor people have fewer possible actions available to them than do rich people. With wealth comes access. The rich man in the Figure 3.3 can polish his own shoes but can also pay somebody else to do this. The poor man does not even have shoes that need to be polished let alone resources to pay somebody else to polish the shoes. This example shows that not every person can occupy each possible position in an action situation. Both men can occupy the positions of citizen, or legal adult, but only the wealthy man can be both polisher and "polishee." The fact that the poor man cannot be the "polishee" is due to one of two factors (1) formal rules or norms about social roles and occupations allowed for different social roles such as the cast system in India or (2) because the poor man lacks the resources or capacity to be the "polishee." In the first case, it is the **action situation** that limits the actions of the poor man. In the second case, it is an outcome of the **action arena** that limits his choices. Whether an individual can occupy a certain position may be affected by wealth, education, elections, inheritance, passing a test, age, gender, and many other criteria. As we will see in later chapters, the rules that affect positions play an important role in how communities can sustain their commons.

When we study an action situation, we analyze the situation as given. We assume the structure of the action situation is fixed for at least the short run. Then we can analyze the action arena by exploring assumptions of the likely human behavior of the individuals leading to particular outcomes.

Within a particular situation, individuals can make choices about their own actions. However, in the longer term, individuals may—at least those who are living in an open society—take actions that may eventually affect the structure of action situations (i.e., the choices others can make). This is possible when one is able to change the rules affecting the action situation. For example, the rules regarding the marketplace at eBay have changed over time because participants have learned what works and what does not work. If action situations do not lead to good outcomes, one may attempt to change the rules. To do so, they must move to action situations at a higher level of decision making such as *collective-choice* or *constitutional-choice* action situations, where the outcomes generated are changes in the rules that structure other action situations such as who can participate, what actions are available to them, what payoffs are associated with actions, etc. In a closed society, individuals at an *operational* level may have little opportunity to change rules at any level and may find themselves in highly exploitative situations. Democratic countries are examples of open societies, while dictatorships are examples of closed societies (see Figure 3.4). We discuss the process of shifting to higher-level action situations in the last half of this chapter.

3.2 The basic working parts of action situations

Let us now discuss the elements of an action situation so we can begin to understand what is common to all of the interactive situations we may observe or experience in our lives.

3.2.1 Participants

Participants in an action situation are assigned to a position and capable of making a choice between different possible actions. The participants in action situations can be individuals but also corporate actors such as nations, states in a federal system, private corporations, NGOs, and so forth. Whenever participants are organizations, one treats them in the situation as if they were a single individual but one that is linked to a series of additional situations within their own organization. When one is interested in the outcome of an action situation for the

organization, we may ignore the linked situation and just focus on the strategy of the organization as an individual actor. However, if we notice that there are problems with the functioning of an organization within an action situation, we may look at the functioning of the organization itself, and study the action arena of that organization. As such, action arenas can be composed of action arenas of lower level actors. For example, the United Nations consists of many countries. To understand the functioning of the action arena of the United Nations, we may look at the ambassadors as participants, or we may look into the action arena of a country in which the ambassador also participates to understand the decisions made by that ambassador.

Figure 3.4: North Korea is an example of a closed society. Citizens have no control over the decisions they can make, have no control over the information they receive, and have no ability to change regulations.

Several attributes of participants are relevant when representing and analyzing specific situations. These include (1) the number of participants, (2) their status as individuals or as a team or composite actor, (3) and various individual attributes, such as age, education, gender, and experience.

The number of participants

The focus of this book is the action situations associated with the commons. Therefore, action situations that are of interest to us require at least two participants where the actions of each affect the outcomes for both. This could be two farmers sharing a water source.

The *specific* number of participants is often specified in detail by formal regulations, such as for legislation (number of seats in the Senate and Congress), juries (number of jury members), and most sports (number of members on a team). Some descriptions of a situation, however, specify the number of participants in a looser fashion such as a small or a large group, or face-to-face relationships versus impersonal relationships. Since many other components of an action situation are affected by the number of participants, this is a particularly important attribute in the analysis of any action situation. Figure 3.5 shows some examples from sports illustrating the number of participants in action situations.

The individual or team status of participants

Participants in many action situations may be individual persons or they may represent a team or composite actors, such as households. A group of individuals may be considered as *one* participant (a team or organization) in a particular action situation. What might be the conditions in which it makes sense to treat a group of individuals as a participant?

To consider a group of individuals to be a participant, one must assume that the individuals intend to participate in collective action. One needs to assume that the individuals who are being treated as a single actor intend to achieve a common purpose. Sometimes there are groups of individuals who share many similar characteristics, such as "veterans," "urban voters," or "legal immigrants," but they have different individual preferences and do not act as a cohesive team. Corporate actors, such as firms, are not so dependent on the preferences of their members and beneficiaries, because they are legally defined as an individual entity. The activities in firms and organizations are carried out by

Figure 3.5: Different numbers of players in the action situation: a) two sumo wrestlers, b) eleven players per soccer team c) 200 cyclists in a stage of the Tour de France, and d) more than 10,000 runners in a marathon.

staff members whose own private preferences are supposed to be neutralized by formal employment contracts.

A fully organized market with well-defined property rights, for example, may include buyers and sellers who are organized as firms as well as individual participants. Firms are composed of many individuals. Each firm in a market is often treated as if it were a single participant.

So when do we consider a group of individuals as a collective rather than as a bunch of individuals? This depends on the questions we have. The action arena of a basketball game, for example, may be represented as having either ten participants or two teams composed of five individuals. If we are interested in studying a league or a tournament, we will include more teams and focus on the teams as participants rather than as individual players. If we are interested in the performance of a single team within the league we would look at individual players, coaches, trainers, and owners.

Attributes of participants

Participants differ in their characteristics such as their skills, ethnic background, education, gender, values, etc. These characteristics may influence their actions in some situations, but not in others. The educational level of participants is not likely to affect the actions of drivers passing one another on a busy highway. But when the participants meet each other in an emergency room in the positions of patient and physician, education becomes an important attribute. Whether gender or ethnic background is important varies between cultures and countries. In some cultures, female patients are not allowed to be examined and treated by male physicians. During the Apartheid regime in South Africa, Black patients did not receive the same treatment as White patients did.

The outcomes of many situations depend on the knowledge and skills of the parties. Experienced drivers will have on average a different driving style compared to younger drivers. This fact is born out in the differences between insurance policies for the two participants. Drivers who have a

reputation with an insurance company for getting involved in accidents will have to pay a higher insurance premium compared to those who are accident free.

3.2.2 Positions

Participants occupy positions in action situations. Examples of positions include students, professors, players, referees, voters, candidates, suspects, judges, buyers, sellers, legislators, guards, licensed drivers, physicians, and so forth. It is very important to understand that "positions" do not refer to people, but rather to **roles** that participants can play in an action situation. For example, in a market situation (in your local mall), the same person may be a "seller" when she is at work at the Apple Store helping customers choose their latest iPhone, and a "buyer" when she goes for lunch in the food court. Thus, positions and participants are separate elements in a situation even though they may not be clearly so identified in practice.

In practice, the number of positions is frequently significantly less than the number of participants. In a class there are typically only two positions—student and professor—while there may be hundreds of participants. Hunters who have a valid license all occupy the position of a licensed hunter; and while there are more than a billion participants at Facebook, there are only a limited number of positions (such as the person featured on the webpage, or the administrator of a page representing an organization).

Depending on the structure of the situation, a participant may simultaneously occupy more than one position. All participants will occupy whatever is the most inclusive position in a situation — member, citizen, employee, and the like. In a private firm, additional positions such as foreman, division manager, or president will be occupied by some participants while they continue to occupy the most inclusive position—that of employee. Some examples of positions are given in Figure 3.6, where some positions are filled by election, others are filled by selection after an interview.

Positions connect participants with potential actions that they may take in an action situation. Not all positions have the same potential actions. A surgeon can do surgery on a patient. It is likely not advisable to allow the patient this potential action, unless in the unlikely event that the patient happens to be a surgeon too. Other positions are less restrictive. Every person with a driver's license shares a large set of potential actions with every other driver. Some drivers have a special positions and additional potential actions, such as drivers of ambulances or large trucks.

The president of the United States can sign a bill into new legislation, which confirms that the new legislation will be implemented. The president can only sign such a document under particular conditions (agreement in the Senate and Congress), but a signature of a regular citizen does not have the same effect. A U.S. citizen who has registered as a voter can vote, but a permanent resident (Green Card holder) cannot register as a voter, even if such a permanent resident is a professor at a prominent university.

The nature of a position assigned to participants in an action situation both defines the set of authorized actions and sets limits on those. For example, licensed drivers *may* operate a motor vehicle on a road or highway, but this action is also restricted by speed limits. Those who hold the position of a member of a legislative committee are authorized to debate issues and vote on them. The member who holds the position of chair can usually develop the agenda for the order of how issues will be brought before the committee or even whether a proposal will even be discussed. The order of events on this agenda may affect how the votes turn out.

If you do a group project how do you organize a group? Will different group members have different roles? Is one of the members leading the discussion?

Figure 3.6: a) Barack H. Obama in the position of President of the United States of America, b) the U.S. Supreme Court, c) judges on the television show American Idol, and d) a police officer.

Participants may occupy different positions, but which position one can be hold is not always something a participant can choose. A defendant in a criminal trial does not control her movement into or out of this position. A candidate for the U.S. Congress can certainly influence her chances of winning an election and securing the position, but does not have full control. In the end, this decision is in the hands of voters. Holding the position of a pedestrian in traffic is available without much limitation to most people. Individuals have to compete vigorously for getting a tenured professorship at a university, but once obtained, they may hold their positions for life, subject only to legal actions. This might be true for universities in the U.S., but in most European countries professors are required to retire at the age of 65 and are removed from their position as a tenured professor.

3.2.3 Potential outcomes

In the case of health care reform, there are different potential outcomes that can be discussed: total costs of health care, access to health care, distribution of costs and benefits, quality of health care, etc. Which outcome will weigh most in the design of policies is a political decision.

Figure 3.7: The BP Deepwater Horizon oil rig ablaze.

When we want to understand how rules, attributes of the environment, or attributes of the community change an action situation, careful attention must be given to how participants value certain outcomes. If there is a market where goods are exchanged at known prices, one could assign a monetary value to the goods. If there are taxes imposed on the exchange of goods (a sales tax), one could

represent the outcomes in a monetary unit representing the market prices minus the tax. If one wanted to examine the profitability of growing rice as contrasted to tomatoes or other cash crops, one would represent the outcomes in terms of the monetary value of the realized sales value minus the monetary value of the inputs (land, labor, energy, fertilizer, and other variable inputs).

To examine the effect of rules, one needs to distinguish the effect of material rewards from financial values. For example, the physical amount of goods produced during a particular time period is different than the financial rewards to workers and owners for that time period. If no goods are sold, the financial rewards for the owner might be negative, but the worker may still receive a reward in exchange for the hours worked to produce the goods. Besides monetary values and physical quantities of goods, participants also have internal values, such as moral judgment, that they use to examine potential outcomes. Gun ownership can be evaluated based on the numbers of different types of guns owned, the monetary value of the gun collection and the moral value placed on gun ownership.

Frequently the outcomes are assumed to be the consequence of self-conscious decisions, but there can also be "unintended outcomes." For example, oil spills in the Gulf of Mexico are not an intended outcome of operations of oil companies (Figure 3.7).

3.2.4 Actions

Participants assigned to a position in an action situation must choose from a set of actions at any particular stage in a decision process. An action can be thought of as a selection of a setting or a value on a control variable (e.g., a dial or switch) that a participant hopes will affect the outcomes. The specific action selected is called a *choice*. A complete specification of the actions, taking in all possible variations of the action situation is called a *strategy*. It is important to note that it might not always be clear to participants what all the valid actions are in an action situation. A switch may clearly indicate two different positions, but sometimes participants are much more innovative in the use of possible actions in an action situation. Calling somebody with a mobile phone can be very expensive in some places. As a result, people may use the technology in a different way than was intended by the manufacturers. For example, in some communities, signaling systems evolved where the receiver of a mobile phone call can understand the message from simply counting the number of rings of the call and the information about who the caller is from the display. Users in such situations may seldom use their mobile phone for an actual voice call. What is the change of outcome for the mobile phone service provider when people use this strategy?

Figure 3.8: Possible actions.

3.2.5 Control

The extent to which participants have control over aspects of the action situation vary widely. Obviously, the position that a participant occupies affects the power of this participant (her ability to affect the actions of other participants and outcomes). The level of control a participant has can therefore change over time, for example if she changes her position. Barack Obama acquired a new repertoire of actions and control when he assumed office on January 20, 2009. And this repertoire

has changed over the years from being a lecturer and giving grades at the University of Chicago, a community organizer, a member of the Illinois Senate, and a member of the U.S. Senate. Each position held certain duties and rights. Leaving a position also means losing the duties and rights that hold to the specific position.

3.2.6 Information about the action situation

What is the information participants have in an action situation? In an extreme case they have complete information and know the number of participants, the positions, the outcomes, the actions available, how the actions are linked to outcomes, the information available to other players and the payoffs available. If they know what other participants will do, participants are said to have perfect information. Of course, perfect information is an extreme case especially when people make their decisions privately. Often there is no perfect understanding of how actions will lead to outcomes, or what others plan to do. Even if people communicate and negotiate what everyone will do, the actual actions may turn out different since people make mistakes or cheat.

In many situations there is asymmetric access to the available information. For example, in work situations, a boss cannot know exactly what employees are doing. That is why providing an incentive to increase productivity is a challenge. The same holds for insurance companies. Your insurance company does not have perfect information about your driving abilities and health conditions, but makes an informed guess based on statistics of historical events. Would you like your insurance company to have access to your genetic profile? What about your driving behavior? The car insurance company Progressive allows customers to join a voluntary program where a device is installed in your car to track your driving style. One can save a significant amount on their car insurance with proper driving style.

3.2.7 Costs and benefits

To evaluate the outcomes of the actions taken in the action situation we have to look at the costs and benefits. These costs and benefits accumulate over time. Not all participants will experience the same costs and benefits. Sometimes the positions that participants hold affect their cost and benefits since it affects the compensation, penalties, fees, rewards and opportunities. A physician receives a monetary benefit from doing a treatment while the patient will pay to receive an improvement in their health condition. Even if participants hold the same position, like players on a sports team, their rewards vary as defined by their individual contracts.

Figure 3.9: The monitoring of speeding.

If we study action arenas we need to make a distinction between the physical outcome and the valuation that a participant assigns to that outcome. In economics, the value assigned by participants is often referred to as *utility*. Individual utility is a summary measure of all the net values to an individual of all the benefits and costs of the outcome of a particular action situation. Utility might increase with an increase in profit, but depending on the study at hand, it may also include elements like joy, shame, regret and guilt.

For example, driving above the speed limit can save you time. However, if you are caught you will have to pay a traffic fine (Figure 3.9). You may challenge a ticket by appearing in court, yet this will take time and may have other costs associated with it. Paying the fine (accepting guilt for

the traffic violation) could also result in higher car insurance and accumulate points on your driving record. If you accumulate too many points on your driving record, your license may be suspended. Not paying a ticket in time will lead to additional penalties.

3.2.8 Linking action situations

In reality people make decisions in different action situations that are often linked together. Rarely do action situations exist entirely independently of other situations. For example, new laws in the U.S. need to be approved by the Congress and the Senate before the president may sign it. Signing a bill is meaningless unless the bill has successfully passed through the Congress and Senate action arenas.

Given the importance of repeated interactions to the development of a reputation for reciprocity and the importance of reciprocity for achieving higher levels of cooperation and better outcomes over time, individuals have a strong motivation to link situations.

Action situations can be linked through organizational connections. Within larger organizations, what happens in the purchasing department affects what happens in the production and sales department and vice versa. Sometimes action situations are structured over time. For example, a tournament or sport competition is a description of how players (e.g., tennis) or teams (e.g., basketball) will proceed through a sequence of action situations. In other examples, action situations are not formally linked. Farmers who have successful innovative practices in deriving better profits are frequently copied by others.

Another way in which action situations can be linked is through different levels of activities. We can distinguish three levels of rules that cumulatively affect the actions taken and outcomes obtained:

- *Operational* rules directly affect day-to-day decisions made by the participants in any setting. These can change relatively rapidly—from day to day.
- *Collective-choice* rules affect operational activities and results through their effects in determining who is eligible to be a participant and the specific rules to be used in changing operational rules. These change at a much slower pace.
- *Constitutional-choice* rules first affect collective-choice activities by determining who is eligible to be a participant and the rules to be used in crafting the set of collective-choice rules that, in turn, affect the set of operational rules. Constitutional-choice rules change at the slowest pace.

An example of an operational-level situation is a group of fishers who decide where and when to fish. At the collective-choice level the group of fishers may decide on which seasons or locations to implement bans on fishing. At the constitutional-choice level decisions are made regarding the conditions required in order to be eligible for membership in the group of fishers.

Figure 3.10 illustrates the different levels of rules related to a class at a university. Within a classroom, decisions are made based on the rules set in the syllabus. Day-to-day decisions include what the assignments are for next week, who will give a talk, and when students can come to office hours. In order for a regular course to be approved, a committee (upper right) will review the proposed syllabus and make a recommendation to approve or not approve the course. The committee also solicits comments of departments that provide similar courses to avoid potential conflicts. The university senate will come into play when new degrees are proposed (middle left). Finally, the upper administration of the university will be involved in decisions that have university-wide impact, such as changing tuition rates. Such a tuition raise will have to be approved, at least for public universities,

Figure 3.10: Different levels of rules related to a university class (clockwise): a) day-to-day assignments; b) syllabi are approved by committee; c) university senate approve new degrees; and d) upper administration make decisions that have university-wide impact, such as tuition rates.

by a state level committee.

3.2.9 Outcomes

It is difficult to predict the outcomes of rule changes made in action situations. Changing the rules in one action situation may have consequences in other action situations. The difficulty of predicting the consequences of changes shows that we have to closely observe what is happening before rules are changed and after rules are changed. This suggests that we should view policies experiments, and closely observe these experiments in order to learn and have a better understanding of what will happen in a similar case in the future.

Besides the difficulty of predicting outcomes, how to evaluate outcomes is also often not immediately evident. There are different criteria that one can use to evaluate the outcomes:

- Economic efficiency—what are the costs relative to the benefits?
- Equity—how are costs and benefits distributed among the participants?
- Accountability—are participants in leadership positions accountable for the consequences of their decisions?
- Conformance to general morality—are the procedures fair, is cheating detected, and are promises kept?
- Sustainability—how do the outcomes evolve over time? And what are the consequences of decisions on the underlying system?

In order to evaluate the outcomes one needs to evaluate trade-offs associated with the different criteria. If some groups are affected differently than others, it will be important to define procedures in the collective-choice or constitutional-choice rules to address such differences. For example, the outcome of changing the criteria for student-loans will not have the same consequence for each individual student. It would be important to consider the different types of outcomes for different types of participants and develop agreements regarding how to evaluate such outcomes.

3.3 Critical reflections

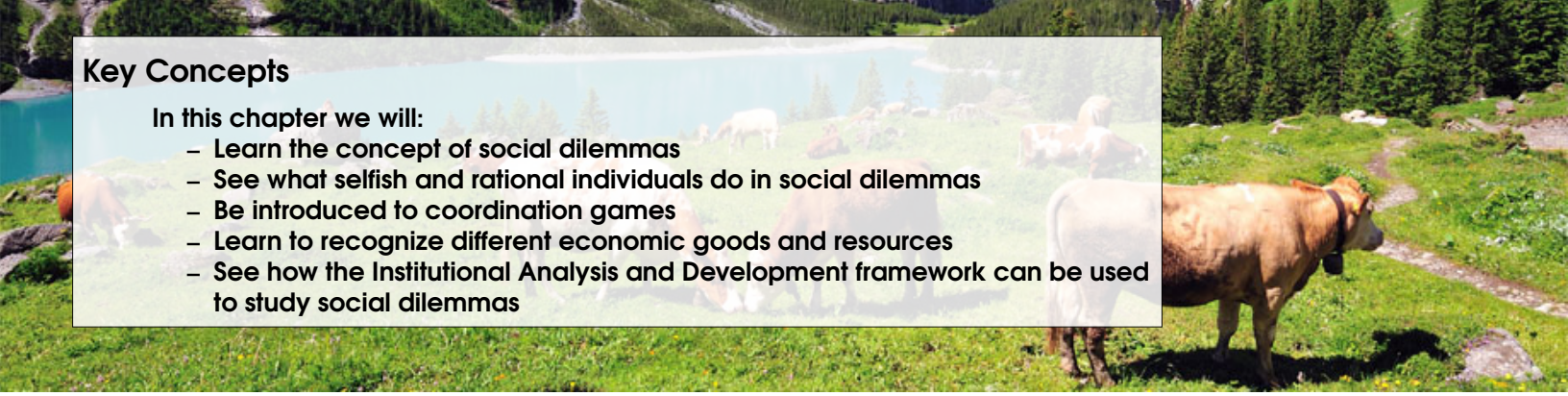
The concept of **action arenas** was the main topic of this chapter. An action arena consists of an **action situation** that defines the structure of interactions, actions and outcomes, and the individuals, organizations or nations who may participate in the action situation. When two or more participants interact, there is an action arena where participants hold **positions**, and can make decisions. Not everybody in an action situation can take the same **actions**, or has the same level of **information**. The consequences of the actions are the **outcomes** of the action situation, which can be **evaluated** differently by each participant in the action situation.

3.4 Make yourself think

1. What positions do you hold in different action situations? Provide some examples.
2. What is an action situation you experience regularly? What are the possible outcomes in this situation? What actions can you take? Be sure to distinguish between actions you may take and choices you do make.
3. Do you have an example from your own personal experience where you have experienced the same action situation but with different participants that led to a different action arena and a different outcome?

3.5 References

Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.



Key Concepts

In this chapter we will:

- **Learn the concept of social dilemmas**
- **See what selfish and rational individuals do in social dilemmas**
- **Be introduced to coordination games**
- **Learn to recognize different economic goods and resources**
- **See how the Institutional Analysis and Development framework can be used to study social dilemmas**

4 — Social Dilemmas

Tropical Holiday

Figure 4.1: Tropical Island

You have worked hard during the last few months and long for a relaxing week away from home. You have booked a holiday on a tropical island thinking it would be a great opportunity to reenergize. You deserve this. A friend, who is conscious about sustainability issues, wonders why you need to go to this exotic island. The flight alone will consume most of your annual carbon budget. This annual carbon budget is defined as the per person average annual carbon emissions allowed if your country were to meet the emission levels required to avoid dangerous climate change. By going on this tropical holiday, you will produce higher than average emissions compared to your fellow citizens. Because of your holiday, others will have to emit less carbon if the nation is to meet its emission targets. You argue that the plane is flying anyhow so your trip would not really generate an extra amount of emissions. Furthermore, your trip will contribute to employment and economic growth. Why should you suffer by not going to a tropical beach so that the "group" can meet its sustainability goals? What would you do?

4.1 Introduction

In many action situations we experience every day, there often exists a dilemma between what is best for the individual and what is best for the group. For example, it would be beneficial for an individual to be able to use a siren so that all the other cars on the road will pull over, allowing the one with the siren to get from point A to point B as fast as possible. It would also be beneficial to an individual not to pay taxes. Nevertheless, society would not function if everybody used a siren when they drove or did not pay their taxes. In general, society will not function if individuals do only what is best for themselves alone. This is called a social dilemma.

The study of social dilemmas is a very prominent topic in the social sciences. In this chapter we will discuss different types of social dilemmas and describe them from the perspective of the action situation we covered in the previous chapter.

We will see that social dilemmas lead to the prediction that people will not contribute to the common good or will overharvest from shared resources. But as we will see in later chapters, these

predictions are based on a very narrow notion of human behavior, namely that everyone behaves as selfish rational beings. In later chapters we will discuss behavioral studies that show that this is not the case. Nevertheless, it helps to think about social dilemmas using the naïve model of decision-making. It will point to some potential problems related to action situations.

The very existence of Wikipedia demonstrates that we do not all behave as selfish rational beings. (Figure 4.2). Many people now use Wikipedia because it is a very powerful resource with high quality information on many topics. There are fewer people who write articles for Wikipedia than there are people reading Wikipedia articles. Those people who only consume Wikipedia "free ride" on the contributions of others. Those who write articles spend time (experience a cost) to do so. Luckily there are enough people willing to make a contribution voluntarily in order to have a very useful product. If people are fundamentally selfish, why do you think these individuals contribute to Wikipedia?

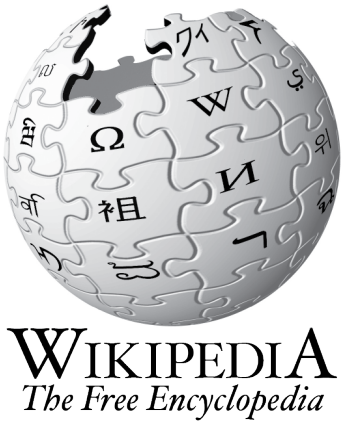


Figure 4.2: Wikipedia logo.

Have you ridden a bicycle to school lately? Decided not to go on vacation? Or switched to a vegetarian diet? Some people have elected to adopt these types of changes in their lives in order to reduce greenhouse gas emissions and reduce the possible impacts of climate change. However, many more people will need to change their behavior in order to solve this social dilemma than are currently doing so. Although policy makers have discussed climate change for more than 20 years, global emissions continue to increase almost every year. This is an example of a social dilemma (and there are many like it) that cannot be solved by voluntary contributions alone, indicating that regulations to stimulate action (e.g., lower energy use) are needed. That is why we will talk about rules and norms in later chapters. We may need to use rules and norms to overcome social dilemmas.

4.2 Prisoner's dilemma

A classic description of a social dilemma is captured in the prisoner's dilemma. This dilemma was originally developed in 1950 by Merrill Flood and Melvin Dresher working at RAND. The basic idea is as follows: There is a riot leading to plundering in the city by youngsters and two suspects are arrested by the police. The two suspects did not know each other before the riots and the police do not have sufficient evidence for a conviction. Having separated the prisoners, the police visit them alone offering each one a deal for testifying against the other. If one testifies for the prosecution against the other (defection) and the other suspect remains silent (cooperation), the defector goes free and the silent accomplice receives the full one-year sentence. If both remain silent, both suspects will receive one month in jail for a minor charge of, say, disturbing the peace. If each betrays the other, each receives a three-month sentence. Each prisoner must choose to betray the other or to remain silent. Each one is assured that the other does not know the decision before the end of the investigation. How should the prisoners act?

We can apply some formal methods to reason through what the best strategy is for the prisoners. But in doing so, we first make some assumptions. Both prisoners want to minimize the amount of time in jail for themselves and they both reason rationally. Both prisoners also assume that the other prisoner reasons like she does. If the first prisoner remains silent, the best decision for the second prisoner is to betray so she can go free. And if the first prisoner testifies against the second, it will,

again, be best for the second to betray. So, whatever the first prisoner does, the best decision for the second is to testify and betray the other. Since both prisoners reason in that way, the expected outcome will be that both betray and both will spend three months in jail.

Obviously, the best solution for both of them would be to remain silent so that both only receive one month in jail. Hence when each reasons what is best for them individually and acts on it, we arrive at an outcome that is not the best for the both of them. The assumptions we have had to make to arrive at this conclusion, however, are pretty restrictive. What have we left out regarding the behavior of the prisoners that might change the outcome?

In Table 4.1 we present the different possible outcomes of this action situation in a so-called payoff table. Depending on what the two individuals decide, there are four possible outcomes. In each cell of the payoff table the payoffs for each outcome is defined.

		Prisoner A	
		Remain Silent	Betray
Prisoner B	Remain silent	One month in prison for both	Prisoner A is free and Prisoner B gets one year
	Betray	Prisoner B is free and Prisoner A gets one year	Three months in prison for both

Table 4.1: Contextual payoff table for the prisoner's dilemma.

This payoff table is often represented in a more abstract way. The story about the prisoners is only one illustration. This kind of social dilemma can be found in many other examples. We often represent the payoff table of this type of action situation, often called a two-player game, by the numerical outcomes for player A and B. In Table 4.2 the outcome (-1, -1) means that both players lose one unit. In this case, currency for the payoff is time. In the original prisoner's dilemma story both prisoners loose one month by going to jail. In other situations, the payoff could be in the currency of water, money, or other valuable resources.

		Player A	
		Cooperate	Defect
Player B	Cooperate	(-1,-1)	(0,-12)
	Defect	(-12,0)	(-3,-3)

Table 4.2: Payoff table for the prisoner's dilemma.

4.3 Social dilemmas as an action situation

As alluded to earlier, we can view the social dilemmas described above from the perspective of an action situation. Let's use the ideas we have discussed so far to dissect the prisoner's dilemma. There are two participants who have equal positions. Both participants have a limited set of actions—they can choose between actions A or B. They have limited information about the other participant since communication is not possible. Both players know that the other player is in the same situation she is in, but do not know what the other player will do. The players only have control over their own

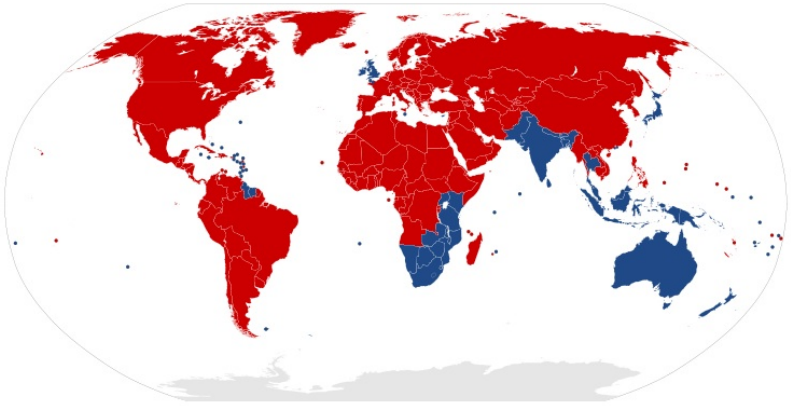


Figure 4.3: The countries in red indicate where cars drive on the right-hand side of the road, while blue indicates where cars drive on the left-hand side of the road.

actions. The outcomes are defined clearly in the payoff table, and the evaluation of the outcomes is based on the material benefits for the players.

If you were in a prisoner's dilemma what would you do? Would it make a difference if you knew the other person, even if you cannot communicate? What does this say about information in an actual action arena? Indeed you can be in the same action situation with two different individuals and have different expectations what the other will do.

4.4 Coordination games

Although the focus of this chapter is on social dilemmas, a related phenomenon is coordination, which can be expressed in terms of a "coordination game." Suppose that while driving a car on a dirty road you decide to drive in the middle of the road since that provides the cleanest surface. Then you see another car coming from the other direction. To avoid a head-on collision, what will you do? You have two options. You can go left or right. If both drivers go right (i.e., from their perspective; from an onlookers perspective, one goes right, one goes left), they will avoid a collision. The same is true if both drivers go left.

Most countries have an established rule for driving on a particular side of the road (Figure 4.3). If you are accustomed to driving on the right side of the road on the mainland of Europe, it can be confusing to drive in the United Kingdom where people drive on the left. Crossing a road as a pedestrian in London can be dangerous if you are not used to cars driving on the left side of the road!

Not all countries have historically used the same side of the road for driving. Sweden, for example, switched from left to right on the 3rd of September 1967 at 5:00 am. The accident rate dropped in the years immediately after the switch, but has since bounced back to levels similar to before the switch. It may be that this pattern is a result of the fact that in the time just after the switch, everybody was more careful in driving since they were used to driving on the left side.

Table 4.3 shows the payoff table for a coordination game. Unlike a social dilemma, individuals cannot free ride on the cooperation of others. If both players drive on the same side of the road in opposite directions, both players receive 10 points. But if they drive on different sides, both will receive 0 points. If both players cannot communicate, it is very difficult to coordinate. In many societies there are social norms that facilitate the coordination. Think about the ways people greet

each other when they meet. If you meet people from different cultures, there might be some initial confusion; shaking with the right hand, giving one kiss on the cheek, or two, or three, giving a hug, or rubbing noses.

		Player A	
		Left	Right
Player B	Left	(10,10)	(0,0)
	Right	(0,0)	(10,10)

Table 4.3: Payoff table for the coordination game.

The next example we discuss is called the "battle of the sexes" (Table 4.4) game. It illustrates the dilemma faced by two players who want to go out at night, but have different preferences. Player A wants to see a movie, but player B wants to go to the opera. Assuming that player A and B, for whatever reason, cannot communicate and have to make a decision where to go, the possible set of actions is movie or opera. If both players do the same, both will receive points, but one will be more satisfied than the other. However, if they end up in different locations, neither will have an enjoyable evening, and both receive zero points.

		Player A	
		Movie	Opera
Player B	Movie	(5,10)	(0,0)
	Opera	(0,0)	(10,5)

Table 4.4: Payoff table for the battle of the sexes game.

A practical example of the battle of the sexes would be a negotiation between two stakeholder groups. For example, a farmer would like to have wind mills on her land to stimulate clean energy. The energy would be available at a low cost to the residents of the nearby town. However, the homeowners do not want their views polluted by wind mills and would prefer to buy the land from the farmer at a price that is higher than the market value, as long as they don't have to look at the wind mills. Whatever option is agreed upon, one of the parties does not receive the best possible outcome. But worse would be that they do not come to any agreement and both parties lose.

4.5 A typology of goods

Many social dilemmas are related to the production or consumption of goods. In this section we describe different types of goods and how rules relate to them. We can use two attributes, exclusion and subtractability, to distinguish four basic goods and services (Table 4.5).

Exclusion relates to the difficulty of restricting those who benefit from the resource or service. *Subtractability* refers to the extent to which one individual's use subtracts from the availability of a good or service for consumption by others. Different levels of exclusion and subtractability define different types of goods. So what do these dimensions actually mean for goods and services? Let's discuss the different dimensions in more detail.

- **Subtractable:** The use of a good or service by one participant in an action arena reduces the availability of the good or service to another participant.

  Examples: A fossil fuel, like oil for example, is a non-renewable resource that is used for many energy sources. The gallons of gasoline that you put in your car cannot be used by somebody else after you have burned the gasoline during your trip. A more direct example is a cake you have made for your friends. Every piece of cake eaten by one person is not available for somebody else. This is related to the old adage "you can't have your cake and eat it too."

- **Non-subtractable:** The consumption or use of the good or service by one participant in the action arena does NOT reduce availability or utility of the good or service to another participant.

  Examples: Reading an article on Wikipedia does not reduce availability of the article for somebody else. Many information goods like movies, photos, books, and scientific knowledge have this property.

- **Excludable:** Any excludable good or service is one that a participant can be prevented from accessing if they do not pay for it, or have passed another form of entry barrier.

  Examples. Going to the movies requires you to buy a ticket to get access. Some websites require you to sign up, like Facebook. You can be excluded if you are too young or have misbehaved in the past.

- **Non-excludable:** Any good or service that a participant cannot be prevented from accessing or it is extremely expensive to exclude.

  Examples: Public roads are available to all cars, even though not all participants pay taxes for the maintenance. It is very costly to deny fishing boats access to the oceans, especially outside the control zones of countries. This makes an ocean fishery very difficult to regulate.

When we combine these two dimensions we can define four different types of goods (Table 4.5): private goods, club goods, public goods and common-pool resources. We will discuss below examples of each of these categories.

	Excludable	**Non-Excludable**
Subtractable	Private goods	Common-pool resources
Non-Subtractable	Club goods	Public goods

Table 4.5: Four basic types of goods.

Let's start with private goods. One can restrict the use of the good easily and when that good is in use, someone else cannot use it. For example, a mobile phone or a car is a private good (Figure 4.4). You can restrict the use of these goods by having password protection or a key. If somebody else takes the private good you can go to the police to report a theft. If you are driving your car, no one else can drive it. If you are making a call on your mobile phone, others cannot use it during your call. Hence private goods are the typical products we own as an individual. Can you think of examples of private services?

The second type is club goods. Compared to private goods, the use of the club good by one person does not affect the use by others. Examples of these so-called club goods are satellite television, cinemas, and toll roads (Figure 4.5). Access is restricted to "members of the club," but

those members can consume the same product. For toll roads it means that you pay a fee to use the road, and moviegoers pay a price for a ticket to watch a movie during a showing.

The provision of goods is more difficult with those for which it is challenging to exclude consumers. Public goods—open source software, Wikipedia, clean air—can be used by everybody, and use by some does not reduce the ability of others to use it. The challenge associated with providing public goods is having a sufficient number of people to invest in their provision. There is a temptation to "free ride" on the contributions of others. Due to the potential for free riding, there might be an underinvestment in public goods. Consider for a moment whether the roads in your city in good condition and are there enough of them? Are there enough parks and open spaces?

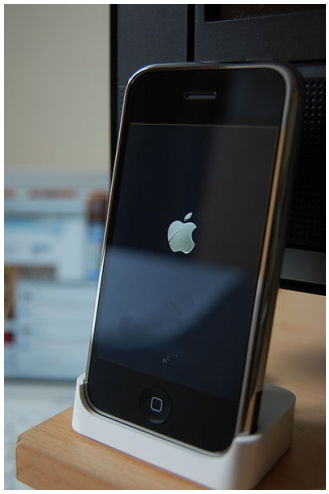


Figure 4.4: Smart phone.

A public road is open to all, but not everybody has provided a contribution to its construction. On a toll road each user must pay to get access to the road, but a public road can be used by those who have not made any contribution (by paying local taxes). The same comparison is true in pay-per-view versus public television. The same physical product can be offered as different types of goods, by changing the rules governing who has access to the good. A public library is a public good for those who want to read a book or newspaper in the library. If you want to take a book home for a limited amount of time, you need to become a member of the library. But if you check out a book from the library no other patron can use that book. So how then is the library a public good? In fact, the story is a bit more complicated as we shall see.

The final example is a common pool resource, such as a lake, an ocean, an irrigation system, a fishing ground, a forest, the Internet, or the stratosphere. These are natural or constructed resources from which it is difficult to exclude or limit users once the resource is provided by nature or produced by humans. One person's consumption of resource units, such as water, fish, or trees, removes those units from what is available to others. Thus, the trees or fish harvested by one user are no longer available for others. The Internet has a limited capacity to move all the information around. Bandwidth that is used by some to watch movies may cause delays in the sending of email by others. The many satellites required for communication (along with space trash from the past) is causing problems for new operations in space.

Figure 4.5: Access to toll roads is restricted to those who are willing to pay a fee.

When the resource units produced by a common-pool resource have a high value and institutional rules do not restrict the way resource units are appropriated (an open-access situation), individuals face strong incentives to appropriate more and more resource units eventually leading to congestion, overuse, and even the destruction of the resource itself. Because of the difficulty of excluding beneficiaries, the free rider problem is a potential threat to efforts to reduce appropriation and improve the long-term outcomes achieved from the use of a common-pool resource. If some

individuals reduce their appropriation levels, the benefits they generate are shared with others whether the others also cut back on their appropriation or not. Some individuals may free ride on the costly actions of others unless ways are found to reduce free riding as an attractive strategy. When free riding is a major problem, those who would be willing to reduce their own appropriations for the benefit of all, provided others would reduce as well, become unwilling to make such a sacrifice for the benefit of a large number of free riders.

Space on Earth is a resource too (Figure 4.6). You have, no doubt, experienced the heavy appropriation of space on the road during rush hour. If enough people drive to work earlier or later than rush hour, this would free up space for others motorists. But who wants to arrive an hour early to work? Or take the bus—an option that might not be convenient for everybody as many people prefer the privacy and control of driving their own car. Hence, the next time you experience a rush hour traffic jam, think about the options everybody has. Due to the free riding behavior, all of the drivers experience lower performance of the road.

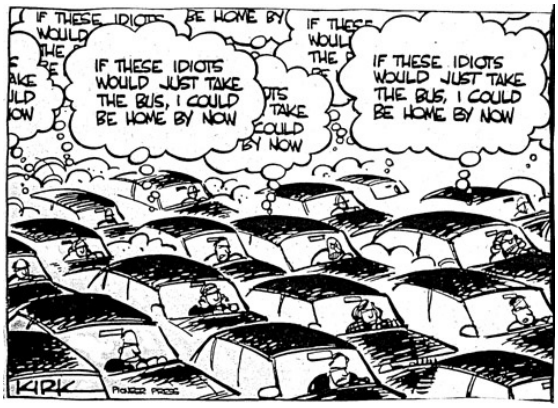


Figure 4.6: Rush hour in traffic.

Let us return to the question of how (or whether) the library is a public good. We have also said that roads are a public good. But we have also mentioned the fact that roads and libraries can become congested. Doesn't that violate the non-subtractability of the resource? It turns out that there are very few examples of **pure** public goods or any of the other goods for that matter. Typically public goods provide multiple streams of services with different characteristics. Further, they must typically be combined with other types of goods to produce a final service. For example, a road isn't much good without a private car, public bus, private scooter, etc. Thus, it is better to think of a road or a library as **public infrastructure** that makes available common-pool resources. In the case of the road, the common-pool resource is transportation space (or capacity). In the case of the library, the common-pool resource is book contact time. The reasonable use of these common-pool resources typically involves solving coordination dilemmas in space and time. Sometimes, three or more types of infrastructure (goods) are combined. Take, for example, the iPhone.

The iPhone itself is a private good. It is useless, however, without a network. The contract you have with the telephone company enables you to use their infrastructure (a club good) to make calls. Many apps can be downloaded for free and used on an iPhone. The ecology of free apps really are pure public goods since they are available without restriction, at least if you have the proper technology to run it. Finally, if many people use their iPhone to watch movies, the wireless bandwidth gets crowded. This is exactly like cars crowding a road: information bits crowd fiber optic and copper cables. The so-called "bandwidth" is a common-pool resource that is made available by telecommunication infrastructure and if too many people start downloading movies the available bandwidth is completely consumed and the wireless signal is not available for anyone else.

As we conclude this chapter, we encourage the reader to reflect on how different types of goods (which we can also refer to as infrastructure) **must** be combined to produce any final service. Yosemite is a "public good." But unless it is combined with roads, cars, or planes, what services can it provide? For some, it does provide a truly pure public good simply in the idea that such a beautiful place exists. For most, Yosemite is, in fact, a piece of public infrastructure that provides a

common-pool resource consisting of "nature viewing time" exactly as the library is a piece of public infrastructure that provides a common-pool resource consisting of "book viewing time." Understanding the subtle nature of how almost all final services are provided by a complex combination of the different types of goods we have discussed in this chapter is a critical prerequisite for designing institutions to wisely govern their use.

4.6 Critical reflections

Social dilemmas are situations in which two or more participants can benefit collectively from cooperation, but an individual who is **selfish** and **rational** can also benefit from **free riding** on the cooperation of others. Four types of goods can be distinguished based on the extent to which it is possible to exclude others and the subtractability of the resource: private goods, toll (or club) goods, public goods, and common-pool resources. In this book we will mainly look at problems of **public goods** (underinvestment) and **common-pool resources** (overuse).

4.7 Make yourself think

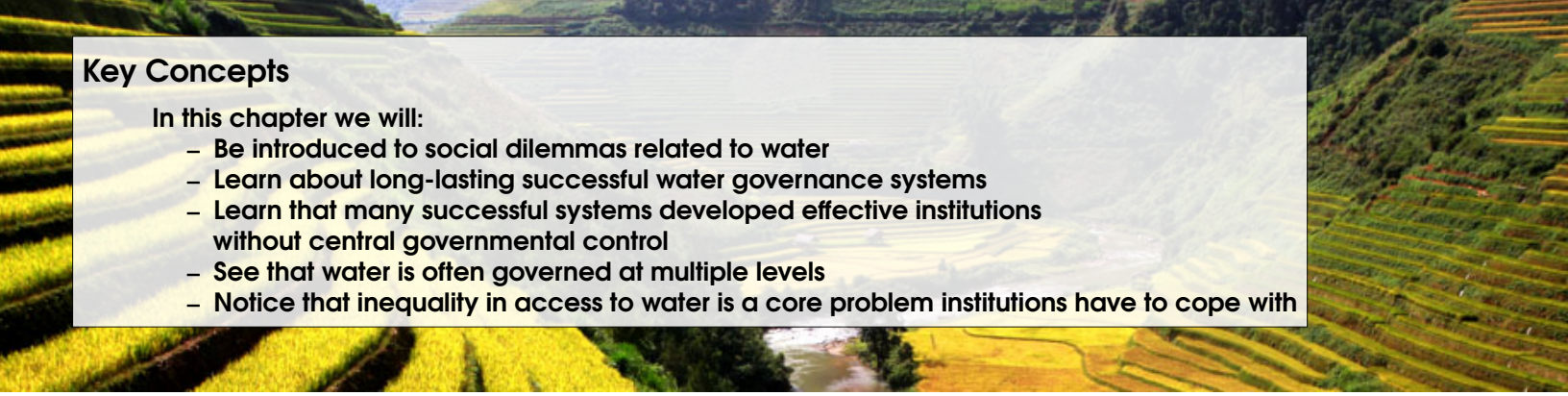
1. Have you ever been in a social dilemma? Describe the dilemma and what you decided to do.
2. What are examples of public goods and common-pool resources you have experienced lately?
3. Why is access to a resource a key component in defining the four types of goods?

4.8 References

Ostrom, E. (1990). *Governing the commons: the evolution of institutions for collective action*. Cambridge University Press.

Part II

Case Studies



Key Concepts

In this chapter we will:

- **Be introduced to social dilemmas related to water**
- **Learn about long-lasting successful water governance systems**
- **Learn that many successful systems developed effective institutions without central governmental control**
- **See that water is often governed at multiple levels**
- **Notice that inequality in access to water is a core problem institutions have to cope with**

5 — Water Governance

Below Sea Level

Figure 5.1: The river dike between Kesteren and Opheusden, the Netherlands, during extreme water levels of the river Nederrijn in 1995.

Although being born and raised below sea level is a common experience for people in the Netherlands, when Elinor and Vincent Ostrom quizzed Marco Janssen about water governance in his country, he had to admit he did not know much about it. When governance is working properly we may not even notice the activities many people are engaged in to bring about success (such as keeping feet dry in the Netherlands and providing water for swimming pools and golf courses in Phoenix). If there is a failure of some kind, a flood or a drought, we are often confronted with the imperfections in the water governance system that led to the failure. In fact, we often see that changes in the operational rules occur after a failure. Such failures are learning opportunities that enable us to improve and adjust the rules. After being confronted with his ignorance, Marco read into the history of Dutch water governance and the description offered in this chapter is a brief overview of this. It illustrates constantly changing circumstances and how human activities change the biophysical context, which subsequently leads to new action situations.

5.1 Introduction

Water governance is the first of many examples that we will present in the remainder of this book on "sustaining the commons" or, unfortunately, "not sustaining the commons" in many cases. We are finally in a position to give a precise definition of the commons. There are two kinds of commons: commons provided by nature, and commons provided by humans. Often these two types of commons interact (e.g., a community irrigation system). The most important distinguishing feature of a "commons" is that it involves one or several *common-pool resources* over which *there are no established private property rights*. The second distinguishing feature of a "commons" is that it involves actions on the part of the individuals who use it to maintain its productivity. These actions are one of two sorts: (1) making a contribution of real resources (money, time, or physical capital), or (2) restricting one's activities with respect to the use of the common-pool resource associated with the commons (e.g., voluntarily fishing less). Actions of type 2 are typically associated with

renewable resources and in this case, are functionally equivalent to actions of type 1: by not fishing, fishers allow the fishery to regenerate itself. This is the same as investing time and effort into increasing the productivity of the fishery. In general, reducing appropriation of a renewable resource is equivalent to investing in natural infrastructure (e.g., a marine ecosystem) that makes the common-pool resource of interest available (fish). The subject of this chapter, water, is a combination of both kinds of commons, the natural infrastructure of watersheds and climate systems and the human-made infrastructure of dams, canals, pumps, and treatment plants. Governing the water commons is arguably the most important issue we face today.

We use water every day to drink, to cook, to shower, to wash, to flush, to clean, to irrigate, to swim in, etc. The importance of water makes it a central object of many social dilemmas: too little clean water, too much polluted water, unequal distributions of water, and natural disasters.

This chapter focuses on water governance. We will discuss some main themes in this field and discuss some in-depth cases to illustrate examples of success and failure when groups attempt to solve the social dilemmas associated with water.

The first theme is **water scarcity**. Large areas around the world suffer from lack of water to meet the demand for human activities (Figure 5.2). There are, of course, different types of scarcity. The areas denoted with *economic water scarcity* do not have sufficient investment in infrastructure (delivery pipes, pumps, etc.) to satisfy the demand for water even though there may be plenty of water available. In this case, the human-made public infrastructure (a type of public good described in the previous chapter) is the limiting factor. Those denoted with *physical water scarcity*, on the other hand, simply don't have enough water available. In this case, it is the common-pool resource (another type of good described in the previous chapter) that is the limiting factor.

To overcome water scarcity in a particular region, water is often imported from other regions and often groundwater resources are tapped in the region with the water deficit. This generates dependencies on other regions and leads to the depletion of groundwater resources. For example, the main urban areas in Arizona are dependent on the Colorado River for their water needs. Due to recent drought conditions, there is less water available in the Colorado River. Right now, Arizona has plenty of water for urban areas as the bulk of Arizona's water, now being used in agriculture, can be transferred to urban uses. However, if the region suffers a prolonged drought, eventually conflict could erupt between the states that use the water in the Colorado River, and Arizona could have difficulty meeting its water needs. In such a situation, the Phoenix metropolitan area would have to rely heavily on its groundwater resources, which could, under extreme circumstances, be depleted.

One drop of water can be used multiple times for different uses, so technically water itself is not subtractable in the sense that the same drop of water used by a city resident to wash their dishes can be used later to water a golf course. This is exactly the same as the situation with a book in our library. One person can read a book now, then someone else can read it later. The key limit is that the resource cannot be used for two different purposes *at the same time*. So, if clean fresh water is being used for washing, flushing, drinking, etc., that same quality of water is not available for other activities at that time. Even though we can use creative coordination mechanisms and technology to recycle shower water to flush toilets, nevertheless, useable water is frequently discarded as waste water to the sewer system or the natural environment. At that point, such water needs to be recollected and treated for reuse. Hence inefficient use of water by individuals leads to a shortage of clean fresh water for the group. Thus, water use is a social dilemma, or as social dilemmas associated with common-pool resources are sometimes called a "commons dilemma."

The second theme is **water overabundance**, which leads to flooding. Extreme rain events are not the only cause of floods. Another factor is land use change, deforestation and canalization of

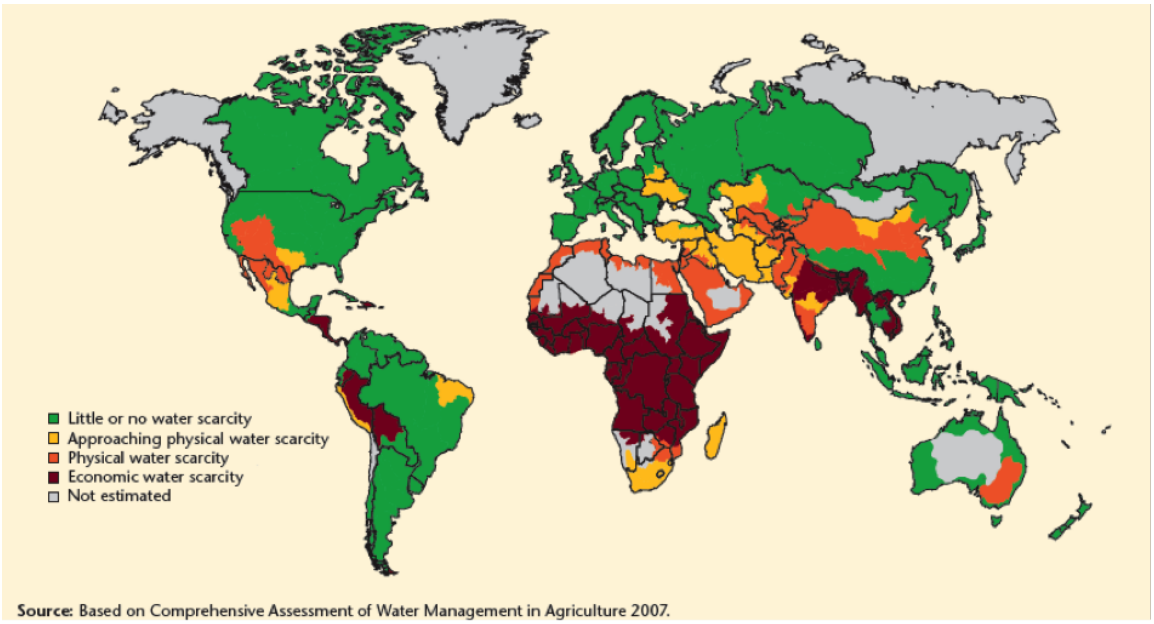


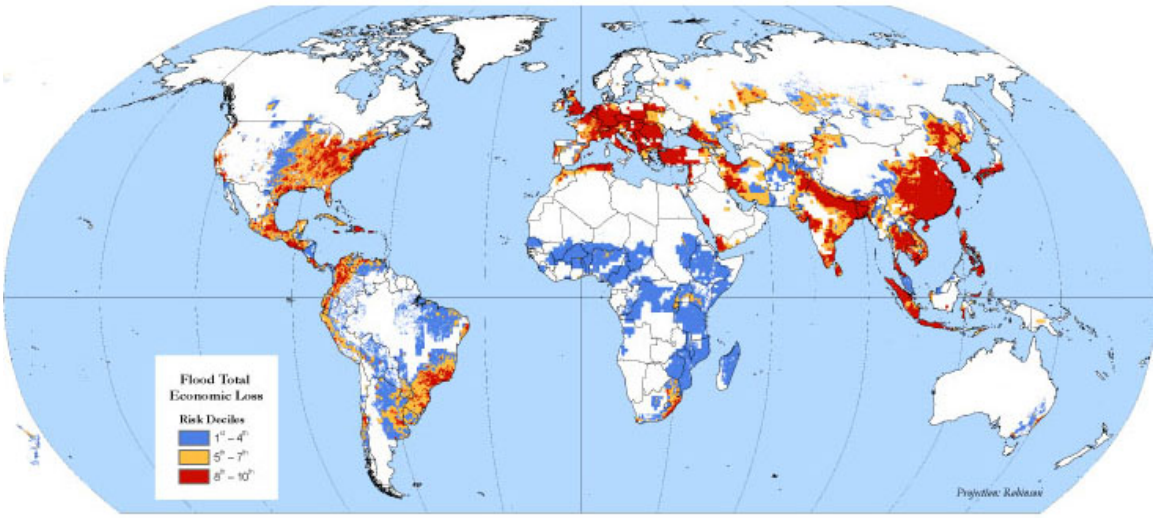
Figure 5.2: Water scarcity.

rivers. These processes reduce the ability of ecosystems to absorb surplus water, causing flood events. Figure 5.3 shows the distribution of damage due to floods over the past 20 years. Note that most damage occurs in the large river basins, such as the Mississippi, the Rhine, the Ganges and the Mekong.

A third theme is **water distribution**. An increasing share of food production is dependent on irrigation where water is distributed from sources (rivers, ground water, lakes, etc), to individual plots of land. About 70% of global freshwater supply is used to irrigate small plots (over 90% of plots worldwide are less than 2 hectares or about 4 football fields). In order to get available water to the right location at the right time, considerable infrastructure is required in the form of irrigation systems and the institutions required to run them.

Figure 5.4 shows the distribution of irrigation areas around the world. Note that the proportion of irrigated land is highest in south Asia. A large proportion of this land is used to grow rice.

Finally, there is a problem with **water pollution**. Waterways can become polluted since rivers are used as sewage systems and to dispose of industrial waste in many countries around the world. Even countries that have developed extensive public infrastructure for waste management still face problems associated with the pollution of waterways. Some of the most common pollutants in rivers in the U.S., for example, are nitrates and phosphates picked up when rain water flows off of agricultural fields into rivers. Such pollution is a classic case of a negative externality: those who benefit from activities that cause the pollution are not the same people who experience the negative effects. Someone pollutes the water upstream causing damage downstream. We will now present a number of cases in more detail to analyze the social dilemmas involved and the various ways people have dealt with these dilemmas.



Total Economic Loss is found by weighting the value of GDP exposure to floods for each grid cell by a vulnerability coefficient to obtain an estimate of risk. The vulnerability weights are based on historical economic losses in previous disasters. The economic loss risks are applied to GDP per unit area exposure to obtain economic loss risks. The weights are an aggregate index relative to losses within each region and country wealth class (classifications based on 2000 GDP) over the 20-year period from 1981 – 2000.

Figure 5.3: Global flood total economic loss risk distribution.

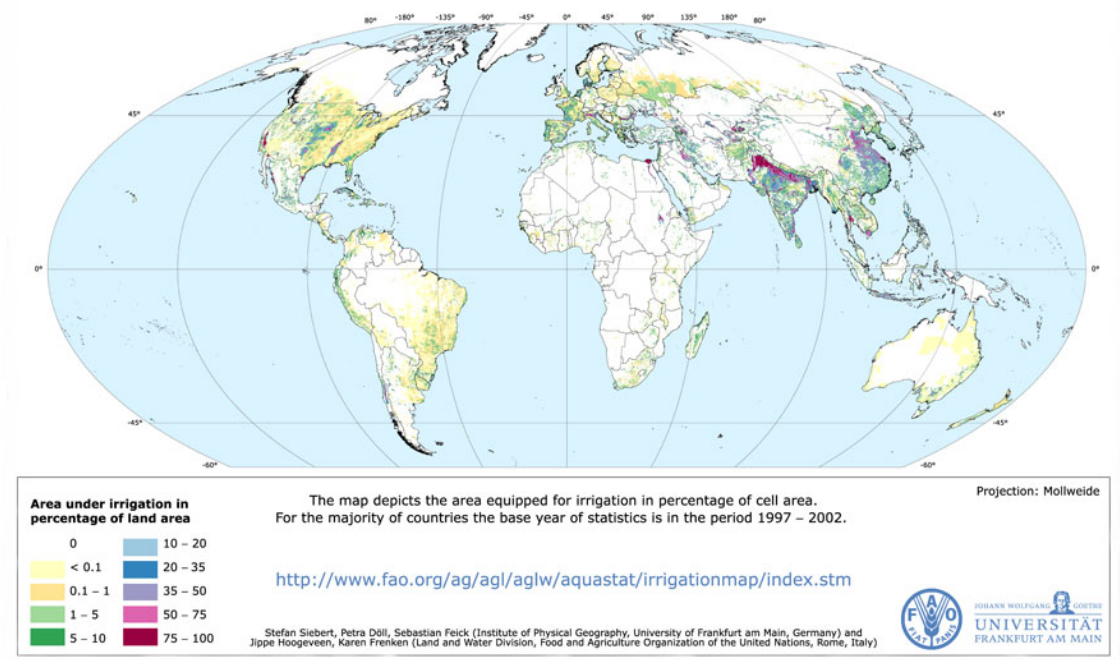


Figure 5.4: Global map of irrigation areas: Percentage of 5-minute grid cell area that was equipped for irrigation around the year 2000.

5.2 Water scarcity

The city of Phoenix was founded in 1861. Since then, the population in the Phoenix metropolitan area has grown to about 4.2 million people (2010). The city has a subtropical desert climate with temperatures up to 118°F (48°C) in the summer, and average annual precipitation of 8.3 inches (210 mm). As places to live go, Phoenix is a harsh climate to be sure (Figure 5.5). This raises the question of why do so many people live in the desert? Where do they get their water from?

Figure 5.5: Phoenix valley.

When the Mexican-American war ended in 1848, Americans started to explore the west in search of riches. One such explorer, Jack Swilling, while on an outing near the White Tank Mountains in 1857, noted an abandoned river valley. This valley, where modern-day Phoenix is located, in fact, has excellent terrain, fertile soils, and an excellent climate for farming. All that was required was water.

Swilling was not the first to recognize the farming potential of the valley. The Hohokam people lived in the valley for more than 1000 years and created 135 miles (217 kilometers) of irrigation canals. The Hohokam were very successful farmers and engaged in an extensive trade network that covered a significant portion of what is now the state of Arizona. There are many archaeological features that attest to the scale of Hohokam irrigation society. After about 1070 C.E. Hohokam society began to change and by 1450, the Hohokam abandoned the valley. The reasons for the abandonment are not known, but might relate to a period of major droughts and severe floods, destroying important infrastructure. It is the remains of Hohokam irrigation systems that sparked Swilling's imagination for what the potential of the valley might be. Swilling built a series of canals following the Hohokam system, thus founding Phoenix. The name Phoenix was chosen to reflect the fact that it is a city born from the ruins of a former civilization. Even today, canals providing Phoenix with water follow the ancient canal systems of the Hohokam.

Initially, Phoenix was a productive agricultural area for cotton and citrus with year-round sun and plentiful irrigation water from the Salt and Gila Rivers. In 1911, the Roosevelt dam was created east of the valley, which provided a more predictable source of water and, with it, the opportunity to grow to a population of 150,000 people. By damming the Salt River, water could be accumulated in the mountains near Phoenix and distributed via irrigation canals. As a result, the Salt River bed that runs through Phoenix is dry most of the time.

In 1922, the seven U.S. states that are part of the basin of the Colorado River created an agreement, called the Colorado River Compact. This agreement defines the allocation of water rights among the states of Colorado, New Mexico, Utah, Wyoming, Nevada, Arizona and California. Based on historical rainfall patterns, the flow of the Colorado was equally divided between the upper division states (Colorado, New Mexico, Utah and Wyoming), and the lower division states (Nevada, Arizona and California).

Defining the rights to Colorado River water created opportunities for irrigation, and led to projects like the creation of the Hoover dam to harvest Colorado River water. Arizona was dissatisfied with the agreement and did not ratify it until 1944. Negotiations dragged on for almost 20 more years until specific disagreements with California were settled in the Supreme Court in 1963. The verdict specifies that California can use 50% of the river flow up to a maximum of 5.4 cubic kilometres annually, Nevada 0.4 cubic kilometres and Arizona the remainder of the lower Colorado river flow.

After solving the allocation problem, the way was cleared for the construction of the largest aqueduct system within the U.S., the Central Arizona Project. Three hundred and thirty six miles of canals bring the water from the Colorado River to the urban areas in the central and southern regions of Arizona (Figure 5.6). The project started in 1973 and took 20 years to complete. Since the 1950s the population in the Phoenix metropolitan area has rapidly increased. This was made possible by the availability of affordable air conditioning. With the rapid growth of the city, agricultural land was transferred into urban use. Although urban use includes golf courses, swimming pools, and the domestic use of water, water use per ha in an urban setting is still considerably less than for agricultural land, which uses a lot of water for irrigation.

Figure 5.6: Central Arizona Project canal.

Nevertheless, since the 1990s there has been a drought that has led to lower water flows in the Colorado River. As water demand continues to grow, the city will either be forced to increase the use of groundwater or to direct ever more water away from agriculture to meet the demand. In order to evaluate the water use challenges for the future of Arizona, Arizona State University has developed a simulation model that enables observers to explore the consequences of droughts, population increase, and water policies. You can explore different scenarios of water use projections at http://watersim.asu.edu/.

The story of the development of Phoenix is the story of how water scarcity was overcome with public goods (infrastructure). There is no way that a small group of individuals could build the Roosevelt Dam. Previous efforts by smaller groups to build canal systems often failed. Getting water to the arid west required a monumental effort. In this case, a central government was essential to provide public infrastructure due to the scale of the problem. This is not always the case. Sometimes smaller groups can solve such large-scale problems, as we shall soon see.

5.3 Water abundance

The Netherlands is a small country in Western Europe. The average income per person is one of the highest in the world. However, 25% of the Netherlands is actually below sea level (Figure 5.7). Furthermore, some of the biggest rivers in Europe cross the Netherlands on the way to their final destination in the North Sea.

In contrast to Phoenix, the Netherlands is a place with an abundance of water. Over time the Dutch have had to solve various social dilemmas to keep their feet dry.

Before 800 C.E. the inhabitants of the precursor of the Netherlands used non-structural measures to keep their feet dry. Such measures like man-made hills or abandoning areas in times of danger were the result of decisions made by individual households. Due to increased population pressure, technological know-how, and finance, there was a rapid increase in the development of structural water control measures after 800 C.E. Such measures included dikes and sluices. Construction and maintenance of these structures required cooperation within communities.

Farmers whose lands directly bordered the dikes agreed to commit themselves to the necessary construction work and maintenance activities. Coincident with the construction of dikes, drainage activities began to be developed as well. To make the lowland area inhabitable, it was necessary to get rid of the extra water. Small dams and sluices were built and maintained, based on similar

agreements as for the flood protection systems between direct beneficiaries. A noticeable difference with regard to input for dike maintenance and small dams and sluices was the fact that in the case of the latter, all beneficiaries had to pay for the benefits received. These dikes, dams, and sluices are all quintessential examples of public infrastructure.

Originally, the local communities in the countryside were in charge of all general collective interests and took responsibility for water management as well. Around 1100 C.E., however, a new adaptation occurred as water management tasks gradually began to become separated from general public tasks. The reason is likely due to the increase in the number and severity of flooding events as well as a growing interdependence and complexity of the hydraulic works that began to stretch beyond the local scale.

Starting at the end of the 11th century and the beginning of the 12th century, the first public bodies charged with governing local and regional water management appeared on the scene and the phenomenon of the *water boards* was born. The purpose of the water boards was to construct and maintain the necessary hydraulic structures, providing safety through dikes and dry feet through drainage (Figure 5.8). Their establishment was recognized by the higher, regional authorities who still held themselves responsible for good water management but who resigned from their administrative duties.

Figure 5.7: Map of the Netherlands with portion below sea level.

Each of the water boards differed in their design and implementation of physical structures as well as rules. They were also confronted with different problems. They were not always successful in preventing floods or draining areas effectively. During the period known as the "Republic of the United Provinces of the Netherlands" from 1581 to 1795, there were severe floods and extensive peat-digging (for fuel), which caused unintended artificial lakes and diverse management problems. Still, the water boards survived this period. One of the main reasons for the long-term adaptation and survival of the water boards is the institutional arrangements upon which they are based. The design of rules was based on the shared norms and values of the population. Although the water boards were not always successful in maintaining safety and dry feet, they were maintained anyway because changing them would be costly. The benefits associated with switching to new and unfamiliar institutional arrangements in an effort to improve performance may have been outweighed by the costs of operating these new institutions. Thus, the water boards maintained the familiar institutional arrangements, which they knew how to operate and that they could adapt. Perhaps the roots of the shared norms in contemporary Dutch society goes back to those people who found ways to make the land liveable by developing institutions based on reciprocity.

Figure 5.8: Windmills at the Kinderdijk, near the hometown of one of the authors.

Since the Napoleanic occupation of the Netherlands in the early 1800s, there has been an increased centralization of water governance over time. Although water boards are still independent organizations, a ministry of water management was created in order to coordinate water management over the entire country. In 1953, a major flood in the south of the Netherlands killed 1800 people. This event led to an increased effort to protect the increasingly urbanized Netherlands from potential floods. As a result, there has been a huge amount of investment in infrastructure made to reduce the risks of flooding over the past 60 years.

Interestingly, major challenges for the future of the Netherlands do not come from the sea. The canalization of the river Rhine has made the river more suitable for the transport of goods to Germany via ships, but it has also reduced the natural buffering capacity of the river. Removal of swamps that naturally would be areas to buffer excess water, now leads to rapid transport of water down the river during rain events. As a consequence, floodings now happen more frequently in the river delta. Upstream countries need to increase their buffer areas to reduce the flooding risks in downstream countries. This situation raises an important point: there are often inherent trade-offs when choosing among performance, robustness (the capacity to cope with change) and robustness to different types of shocks. So the Netherlands has become fairly robust to weather shocks from the sea but, in so doing (occupying more and more low-lying land) it has become more vulnerable to weather shocks from continental Europe (flooding of the Rhine due to rain). Can you run the same mental experiment with the situation in Arizona?

The history of the water boards shows a continuous tinkering with rules at different levels of organization and spatial scales. Disturbances like floods and the unintended consequences of peat digging have triggered the development of new rules and structures. The Dutch water boards illustrate how local-level governance structures may evolve into a resilient collaboration of multi-level governance structures when national institutions recognize the importance of smaller governance units and work with them rather than destroying them.

5.4 Distribution of water: irrigation

Irrigation requires coordination and cooperation. One has to build infrastructure in order to move the water around. This infrastructure needs to be maintained in order to function properly. By maintenance we mean cleaning of the canals and repairing damage to levies and diversion structures. Once the infrastructure is in place, water needs to be shared. In most cases, farmers who have their plots of land near the source of the water have preferential access to the water. In order for downstream farmers to get the water they need, the upstream farmers need to restrict their use of water. But given our earlier discussion of social dilemmas, why would they do this?

The earliest records of irrigation that have been found date to about 8000 years ago in the Middle East (contemporary Iraq and Iran) and independent development of irrigation systems are found all over the rest of the world. There is a wide variety of ways in which infrastructure is built ranging from mud-based canals and simple wooden diversion structures, to concrete canals and computer operated diversion gates.

In 1957, Karl Wittfogel published the book *Oriental Despotism: A Comparative Study of Total*

Power in which he argued that the problems associated with complex irrigation systems are the source of complex societies. In his view, large bureaucratic systems are needed to coordinate labor and supplies required to operate large irrigation systems. These bureaucratic systems, he argues, were then later extended to the rest of society. Although this is an interesting and plausible argument, it rests on a basic assumption: top-down intervention is needed for the operation of large, complex irrigation systems. From many studies of irrigation systems in the last few decades, we see a different story emerging that suggests that this is not necessarily the case. Let's discuss a concrete example.

Bali is one of the islands of Indonesia that has had a complex and very productive irrigation society for about 1000 years. Hundreds of irrigation communities called *subaks* are connected via waterways that begin at a lake near the top of on an old volcano (Figure 5.9). Canals connect this water to subaks downstream. This complex irrigation system has been studied in detail by anthropologist Stephen Lansing and has been made famous in a book titled *Priests and Programmers*.

Figure 5.9: Subak irrigation.

The irrigators have to solve a complex *coordination* problem involving water distribution and pest control (they didn't have pesticides 1000 years ago). On the one hand, control of pests is most effective when all rice fields in a particular subregion are on the same schedule for planting rice. This is due to the fact that the pests (insects called plant hoppers) are limited in their ability to move (or disperse) on the landscape. If large enough areas are kept fallow (areas without plants) between planted areas, the plant hoppers can't cross them because there isn't any food to keep them alive while they cross (i.e., the fallow areas are "food deserts"). This keeps pest outbreaks localized if they occur at all. On the other hand, the terraces (see Figure 5.9) are hydrologically interdependent, with long and fragile systems of weirs, tunnels, canals, and aqueducts used to control where water goes, making it challenging to get the water to all the fields while maintaining large enough fallow areas between planted areas, all in a limited growing season.

To balance the need for coordinated fallow periods and the use of water, a complex calendar system has been developed that determines what actions should be carried out on each specific date. These actions are related to the spiritual practice of making offerings to "water temples" at several levels: little temples at the rice terrace level, the temple at the village level, and the temple at the regional level, associated with the Pura Ulun Swi, "the Head of the Rice Terraces" (this is the temple of the high priest Jero Gde, the human representative of the Goddess of the Temple of the Crater Lake, the main source of water for irrigation). These offerings of water and other items were collected as a counter performance for the use of water that belonged to the gods. These ritual practices trigger the calendar actions (i.e., people make offerings at particular times after which they can plant, etc.).

Balinese society consisted of many kingdoms before the conquest of territory of Bali around 1900 by the Dutch. The Dutch saw these offerings made to the various temples in a different light, namely as a royal irrigation tax. The fact that during the nineteenth century there were quite a number of kingdoms in Bali was a sign that the institution of kingship had weakened over time from one powerful kingdom to a number of smaller kingdoms. Therefore, the Dutch wanted to restore centralized government; in particular they wanted to use a revived royal irrigation tax to improve the irrigation system. The Dutch administrative reorganization failed, partly due to lack of funding, but also because historical analysis conducted during the 1930s demonstrated that there was no evidence

that Bali had ever had a centralized government. Although Indonesia became independent from the Netherlands after World War II, many aspects of the colonial bureaucratic system were adopted by the new independent government.

During the late 1960s, the Indonesian government made self-sufficiency in rice production a major goal for national development. In the same period the Green Revolution began in Asia. The Green Revolution involved the spread of new rice-growing technologies that promised a dramatic increase in rice production. Bali was one of the first targets of the Green Revolution. In contrast to the earlier Dutch attempts to modernize rice production in Bali, this time the engineers were well funded.

The function and power of the water temples were invisible to the planners involved in promoting the Green Revolution. They regarded agriculture as a purely technical process. Farmers were forced to switch to the miracle rice varieties which would produce three harvests a year instead of the two that could be achieved with traditional varieties. Farmers were motivated by governmental programs that subsidized the use of fertilizers and pesticides. The farmers continued performing their rituals, but now they no longer coincided with the timing of rice farming activities. Soon after the introduction of the miracle rice, a plague of plant hoppers caused a huge amount of damage to the rice crops. A new rice variety was introduced, but it was followed by another pest plague. Furthermore, water shortages began to occur because there was nothing to replace the rituals (which were now out of step with plantings) which had been the basis for the efficient allocation of water.

During the 1980s, an increasing number of farmers wanted to switch back to their old ritual-based system, but the engineers interpreted this as religious conservatism and resistance to change. Steve Lansing quotes a frustrated American irrigation engineer "These people don't need a high priest, they need a hydrologist!" (Lansing, 1991, p. 115). It was Lansing who unravelled the function of the water temples, and was able to convince the financers of the Green Revolution project on Bali that irrigation and rice cultivation was best coordinated at the level of the water temples. Lansing built a computer model of the artificial ecosystem, and showed that for different levels of coordination, from farmer level up to central control, the temple level was where decisions could be made to maximize the production of rice.

As this story suggests, the complex irrigation system on Bali and the role of the temples in operating it has evolved over a long history of local adaptations at different levels of organization and different spatial scales. The water temples played a significant role in the coordination of the use of water, but also in providing technical advice and mediating water use conflicts between different subaks. By making offerings to different temples, the farmers were made aware of the interconnections between the water flows at different scales. Due to Lansing's insight and analysis, some of these systems have evolved still further and avoided the fate of many self-organized systems of this kind when experts declared them defunct and constructed new infrastructure without paying much attention to local property rights, ecology, culture, and traditions.

5.5 Water pollution

One of the challenges of water pollution is that the polluter often doesn't experience the consequences of the pollution because the water carries it away (usually toward someone else). This is a classic form of a "negative externality." The polluter gets the benefits of the activities leading to pollution, while the population living where the pollution ends up experiences the costs of the pollution. To illustrate this point, we examine the widespread problem of eutrophication.

Farmers use artificial fertilizers on their land to increase production. Not all the nutrients that

farmers apply are taken up by the plants they grow. The surplus nutrients are picked up by surface water runoff and end up in waterways. Unfortunately, often farmers develop a perception that with fertilizers, more is always better. Even if farmers become aware that some fertilizer is good but after a point it may become detrimental, it is often difficult to determine where this point is in practice. In either case, the basic pattern is that farmers increasingly use more fertilizers.

Eventually, the surplus nutrients (phosphorous, nitrogen, etc.) end up in lakes, seas, and oceans. As a result, many lakes face the challenge of eutrophication where clean, clear water flips into a green soup of algae. Once this happens, the lake cannot be used for recreation and, over time, the algae may kill the fish. Obviously, eutrophication increases the treatment costs if the body of water in question is used as a source of drinking water. Note that the benefits generated through the use of fertilizers are not shared proportionally by the people who experience the costs of eutrophication. Yes, they experience the same reduced cost of food that everyone else enjoys, but bear much more of the cost of that "cheap" food.

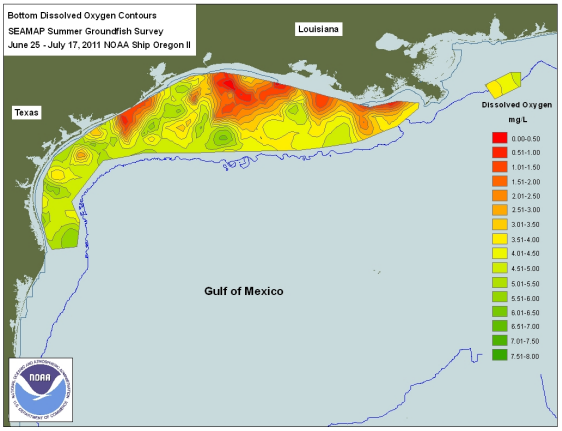


Figure 5.10: Dead Zone in the Gulf of Mexico.

One of the most dramatic consequences of eutrophication is the dead zone in the Gulf Mexico. A dead zone is a low-oxygen area in large water bodies such as oceans. Most marine life cannot flourish in such areas. The dead zone in the Gulf of Mexico consists of more than 22,000 square kilometers of water surface near the coast of Texas and Louisiana (Figure 5.10 and 5.11). The Mississippi River carries nutrients that run off with surface water from the agricultural areas in the midwestern U.S. These nutrients accumulate at the coast near the mouth of the Mississippi. The coastal area is a productive fishing ground that is heavily impacted by the dead zone. Hence, the livelihoods of fishers in the Gulf of Mexico are affected by the actions of farmers in the Midwest.

Figure 5.11: Mississippi River sediment plume entering the Gulf of Mexico near Southwest Pass.

This example illustrates a fundamental challenge with different levels of social organization. Specifically, this problem cannot be addressed by individual farmers talking with individual fishers. Higher level organizations must be part of the solution. How can farmers get incentives to reduce the use of fertilizers? Who will compensate fishers for the loss of productivity they suffer?

Dead zones can be reversed. The North Sea had a dead zone in the 1980s and 1990s. A special organization was created that included all countries in the river Rhine basin. Due to this higher level of coordination, policies were implemented and enforced to reduce sewage and industrial emissions. The nutrient inputs were reduced and the dead zone disappeared. Unfortunately, this is not always the case. If the dead zone is an entire lake, for example, it may be the case that it cannot be restored to a clear, blue state.

5.6 Critical reflections

Water governance has many dimensions. In this chapter we have provided a simple categorization of some of the most important problems we face: water scarcity, water abundance, water distribution, and water pollution. A common challenge in solving social dilemmas related to water is power inequality. Generally, upstream participants have easier access to water and pollution is felt by people downstream. In order to solve these problems, higher level authorities are often needed to coordinate and mediate.

Water is involved with many social dilemmas. People share common water resources, build public infrastructure to protect them from flooding, coordinate when and where to use common-pool water resources and avoid pollution that affects participants in downstream positions.

5.7 Make yourself think

1. Where does the water you use in your household come from?
2. How much water does your household use, and what do you pay for it?
3. What are the main sources of water use in your household, and what can you do to reduce water use?
4. Can you think of how to apply the action arena concept and the IAD framework to the water you are using?

5.8 References

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Key Concepts

In this chapter we will:

- **Be introduced to successful examples of governing the commons**
- **Become aware of the importance of monitoring and enforcement**
- **Learn about paper parks**

6 — Harvesting From the Commons

Rotating Fishing Spots

Alanya, an inshore fishery in Turkey, experienced overfishing in the early 1970s and violence frequently erupted over competition for good fishing spots. In response, the fishers experimented with new institutional arrangements designed to enable them to recover the fish stock and solve problems related to excessive competition. The institutions that the fishers developed are as follows: Each year in September, a list of eligible fishers is prepared, consisting of all licensed fishers in Alanya. All usable fishing locations are named and listed. The stock is such that fishing in one site will not directly reduce the available fish in adjacent sites.

At the beginning of the fishing season the eligible fishers draw lots and are assigned to one of the fishing locations. Each day thereafter each fisher moves to the next location. Under this rotational scheme, all fishing boats have equal chances to fish at the best spots. Fishers are now themselves the monitors. Each fisher knows which spot is available for their turn for each day of the fishing season. If a fisher wants to fish on a productive spot while it is not his turn, the fisher whose turn it is will defend their right to the good spot. Hence, due to the self-monitoring of fishers there is no incentive to cheat.

6.1 Introduction

In his 1968 essay "Tragedy of the Commons," Garrett Hardin argued that people are trapped in an unsolvable problem because they are unable to self-organize equitable and sustainable institutional arrangements. As a result, he argued, outside intervention is required to overcome the overharvesting of what Hardin referred to as "the commons" (what should actually be called open access resources). Although there are many examples of overharvesting of the "commons," this chapter will discuss success stories of self-governance of common-pool resources. These success stories provide insight into which factors may increase the success of self-governance efforts.

We will see that solutions to overcome the tragedy of the commons make use of the physical characteristics of the action situation, and so we distinguish three types of situations in this chapter. In the first type there are domesticated animals. Resource users in this situation must move these animals around the landscape (consistent with the original example used by Hardin concerning sheep sharing a meadow in his now famous paper). The second situation involves the harvesting of wild animals such as fish, lobster or deer (that move around on their own). Finally, the third type of situation involves resources that do not move, such as forests.

6.2 Domesticated animals

Törbel, Switzerland, is a village of about 600 people located in the Vispertal trench of the upper Valais canton. For centuries, Törbel peasants have planted their privately-owned plots with bread grains, garden vegetables, fruit trees, and hay for winter fodder. Cheese produced by a small group of herdsmen, who tend village cattle pastured on the communally owned alpine meadows during the summer months, has been an important part of the local economy.

The earliest known written legal documents are from 1224, and provide information regarding the types of land tenure and transfers that have occurred in the village and the rules used by the villagers to regulate the five types of communally owned properties. On February 1, 1483, Törbel residents signed articles formally establishing an association to improve the regulation of the use of the alp, the forests, and the wastelands.

> The law specifically forbade a foreigner (Fremde) who bought or otherwise occupied land in Törbel from acquiring any right in the communal alp, common lands, or grazing places, or permission to fell timber. Ownership of a piece of land did *not* automatically confer any communal right (genossenschaftliches Recht). The inhabitants currently possessing land and water rights reserved the power to decide whether an outsider should be admitted to community membership (Netting, 1976, p. 139).

The boundaries of the communally-owned lands were firmly established long ago, as indicated in a 1507 inventory document.

Figure 6.1: Cow in Törbel.

Access to this well-defined common property was limited to citizens, to whom communal rights were specifically extended. Here it is important to underscore why Hardin's use of the term "commons" is incorrect. The alpine meadows of Törbel are "commons" (Figure 6.1) in the sense that they consist of a common-pool resource over which there are no *private* property rights. It is property held in common with communal rights. Thus, as we discussed previously, "commons" is not equal to "open access," which refers to property with *no* rights attached. These pastures in Törbel are examples that not all "commons" end in tragedy as Hardin suggested. As far as the summer grazing pastures were concerned (the common-pool resource), regulations written in 1517 stated "no citizen could send more cows to the alp than he could feed during the winter" (Netting, 1976, p. 139). This regulation is still enforced today and provides for the imposition of substantial fines for any attempt by villagers to appropriate a larger share of grazing rights. Adherence to this "wintering" rule was administered by a local official who was authorized to levy fines on those who exceeded their quotas and to keep one-half of the fines for himself. Many other Swiss villages use the wintering rule as a means for allocating appropriation rights (frequently referred to as "cow rights") to the commons. This and other forms of cow rights are relatively easy to monitor and enforce. The cows are all sent to the mountain to be cared for by the herdsmen. They must be counted immediately, as the number of cows each family sends is the basis for determining the amount of cheese the family will receive at the annual distribution.

The village statutes are voted on by all citizens and provide the general legal authority for an alp association to manage the alp. This association, which includes all local citizens owning cattle,

holds annual meetings to discuss general rules and policies and elect officials. The officials hire the alp staff, impose fines for misuse of the common property, arrange for distribution of manure on the summer pastures, and organize the annual maintenance work, such as building and maintaining roads and paths to and on the alp and rebuilding avalanche-damaged huts. Labor contributions or fees related to the use of the meadows are usually set in proportion to the number of cattle sent by each owner. Trees that will provide timber for construction and wood for heating are marked by village officials and assigned by lot to groups of households, whose members are then authorized to enter the forests and harvest the marked trees.

Private rights to land are well developed in Törbel and other Swiss villages. Most of the meadows, gardens, grain fields, and vineyards are owned by various individuals, and complex condominium-type agreements are devised for the fractional ownership among siblings and other relatives of barns, granaries, and multistory housing units. The inheritance system in Törbel ensures that all legitimate offspring share equally in the division of the private holdings of their parents and consequently in access to the commons, but family property is not divided until surviving siblings are relatively mature. Prior to a period of population growth in the nineteenth century, and hence severe population pressure on the limited land, the level of resource use was held in check by various population-control measures such as late marriages, high rates of celibacy, long birth spacing, and considerable emigration.

The Swiss villagers have experienced the advantages and disadvantages of both private and communal tenure systems for at least five centuries, and they continue to use the communal tenure system. Although the yields are low, the land in Törbel has maintained its productivity for many centuries. Netting (1976) associates five attributes to land-use patterns with the differences between communal and individual land tenure. He argues that communal forms of land tenure are better suited to the problems that appropriators face when (1) the value of production per unit of land is low, (2) the frequency of dependability of use or yield is low, (3) the possibility of improvement or intensification is low, (4) a large territory is needed for effective use, and (5) relatively large groups are required for capital-intensive activities.

Figure 6.2: Gaddi shepherds with flock.

Not all owners of livestock own land, private or communal. Nomadic herders, or pastoralists, lead their livestock to graze around a large spatial landscape in order to be at the right place at the right time (Figure 6.2). In such cases, institutions have been developed to gain access to the land of various landowners. Our next example, the complex dynamics of Gaddi shepherds and their landscape in the Himachal Pradesh in India, demonstrates just such a situation. No particular place in this landscape is ideal for the maintenance of goats and sheep throughout the entire year. The only way that these animals can be cared for is to move them across a very large area with highly variable terrain. These pastoralists originally adapted their institutions to the harsh ecological conditions they faced in order to survive. They move their animals, goats, and sheep across a vast mountainous landscape within Himachal Pradesh. During the winter, they descend from the mountains and graze in the valleys and the lower elevation forests. The shepherds have made arrangements with agriculturalists (who own private plots of land) to graze on the stubble left after a harvest from private fields in return for the highly valued manure of the goats and sheep. In the summertime, it is too hot at lower elevations, so

the pastoralists move into the mountains around the tree line. Lyall writes:

> Snow and frost, in the high ranges, and heavy rain and heat in the low, make it impossible to carry sheep farming on a tolerably large scale with success in any part of the country. The only way is to change ground with the seasons, spending the winter in the forests in the low hills, retreating in the spring before the heat, up the sides of the snowy range, and crossing and going behind it to avoid the heavy rains in the summer (Lyall, 1872, p. 46; cited in Chakravarty-Kaul, 1998).

These seasonal movements are based on reciprocal relationships. The Gaddis shepherds invest a lot of time in social networking among themselves and with outsiders to provide access to grazing areas in return for manure and other goods and services.

The informally-evolved rights of the Gaddis shepherds have never been formally recognized by the national government. In 1947, the Indian government adopted policies that reduced the shepherds' access to the usual grazing grounds by building dams to generate hydropower and by providing strictly private property rights to farming communities. This has resulted in more concentrated areas where livestock can graze, and may have contributed to erosion in the forested hilly regions. The government has accused the Gaddis of free-riding within this commons dilemma. However, the government had not recognized the efficient system that the participants in this action situation had already worked out; in fact, the shepherds and agriculturalists had developed an effective bargaining solution by trading manure for grazing rights.

The shepherds adapted to temporal and spatial variability in their system by moving around the landscape in a particular, well-ordered pattern. Activities that hinder this movement pattern on the landscape hit the vulnerable point of this transhumance system (the seasonal movement of people with their livestock between fixed summer and winter pastures). When these movement patterns are affected, the shepherds are forced to use a smaller area which may, in turn, lead to overgrazing. Thus, the transhumance system is highly tolerant to seasonal variation through very specific institutional arrangements, but is extremely vulnerable to changes in access by social or physical barriers.

6.3 Wild animals

The Maine lobster fishery is a remarkable story of self-governance within the contemporary United States. The lobster fishery of Maine is organized into territories along most of the coast. Day-to-day fishing regulations are organized by harbor gangs. These harbor gangs are informal groups that enforce local customs. In order to fish for lobster you need to become a member of a harbor gang, which is the group of fishers who go lobstering from a single harbor. Members of this group can only set traps in the traditional territory of the harbor group. There are various fishing practices that each member is expected to obey (Figure 6.3). These practices vary from harbor to harbor .

To become a member of a harbor community (a formal position) requires participation by family members in that community for several generations. People who are not born and raised in these harbor communities are considered outsiders and will have difficulty gaining the level of acceptance by the rest of the community that is required before the right to fish for lobster would be granted.

In all harbor communities a person who gains a reputation for damaging others' gear or for violating conservation laws will be severely sanctioned. For example, if a fisher goes out to collect his traps, and discovers that somebody else has put traps in the same location, he may signal that this norm violation has been noticed by taking a lobster from the trap and leaving the trap open.

If violations of accepted locations of traps continue, more severe measures can be taken, such as damaging gear and cutting the traps loose.

If a fisher put traps in another gang's territory, similar types of enforcement can be expected. The damages eventually make it unprofitable to continue breaking the informal rules, but are not so severe as to initiate a legal dispute.

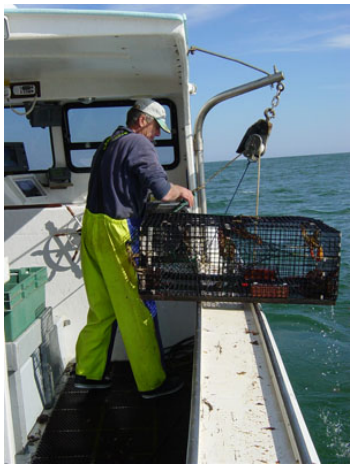

Figure 6.3: Lobster fisher.

There are also formal laws in the state of Maine to protect the breeding stock and increase the likelihood that the regeneration rate remains high. The most important conservation laws are the minimum and maximum size measures, a prohibition against catching lobsters with eggs, and a law to prohibit the taking of lobsters which once had eggs and were marked (i.e., the V-notch law) (Figure 6.4).

When a fisher collects the catch from his trap, he measures each lobster. If it is too small or too big, it will be thrown back. Such a rule avoids catching young lobsters, allowing them to mature to an age at which they will start generating offspring. If a lobster is caught that is carrying eggs, it is a productive female. The lobster will get a V-notch in the tail, and will be thrown back. This is also the case if a lobster is caught with a visible V-notch. This policy ensures that fertile female lobsters are kept alive.

Why would fishers not cheat? How could other fishers find out if a V-notched female were caught? How would they find out if a lobster that is too small was caught? It turns out that the cooperation of the middlemen (the lobster buyers) in the lobster industry is required to prevent cheating. These middlemen do not accept ineligible lobsters because their long-term financial viability depends on a productive lobster population. This gives them an incentive to help enforce the rules (by simply not buying such lobsters).

Figure 6.4: V-notch in tail of lobster. Notice the eggs.

Interestingly, neither the state nor any of the lobster gangs has tried to limit the quantity of lobster captured. Further, the state does not try to limit the number of lobster fishers, since this is already done at a local level. However, the state has been willing to intercede when issues exceed the scope of control of local groups.

In the late 1920s, when lobster stocks were at very low levels and many local areas appear to have had compliance problems, the state took a number of steps (including threatening to close the fishery) that supported informal local enforcement efforts. By the late 1930s, compliance problems were largely resolved and stocks rebounded. Note however, that there are still too many unknowns about lobster biology to make the claim that change in management was the cause of the recovery.

Figure 6.5 shows the decline of lobster catches from the 1880s until the 1930s. The absolute numbers dropped, as well as the catch per trap and per fisher. Since the 1940s the catch numbers have increased, with a rapid increase after 1990. Since the catch numbers per trap and per fisher are also increasing, this suggests that the lobster population is in good condition. If the rapid increase in total catches were caused by overharvesting we would expect a reduction in the catch per trap over time, since a decrease in the total number of available lobsters would cause an increase in the time

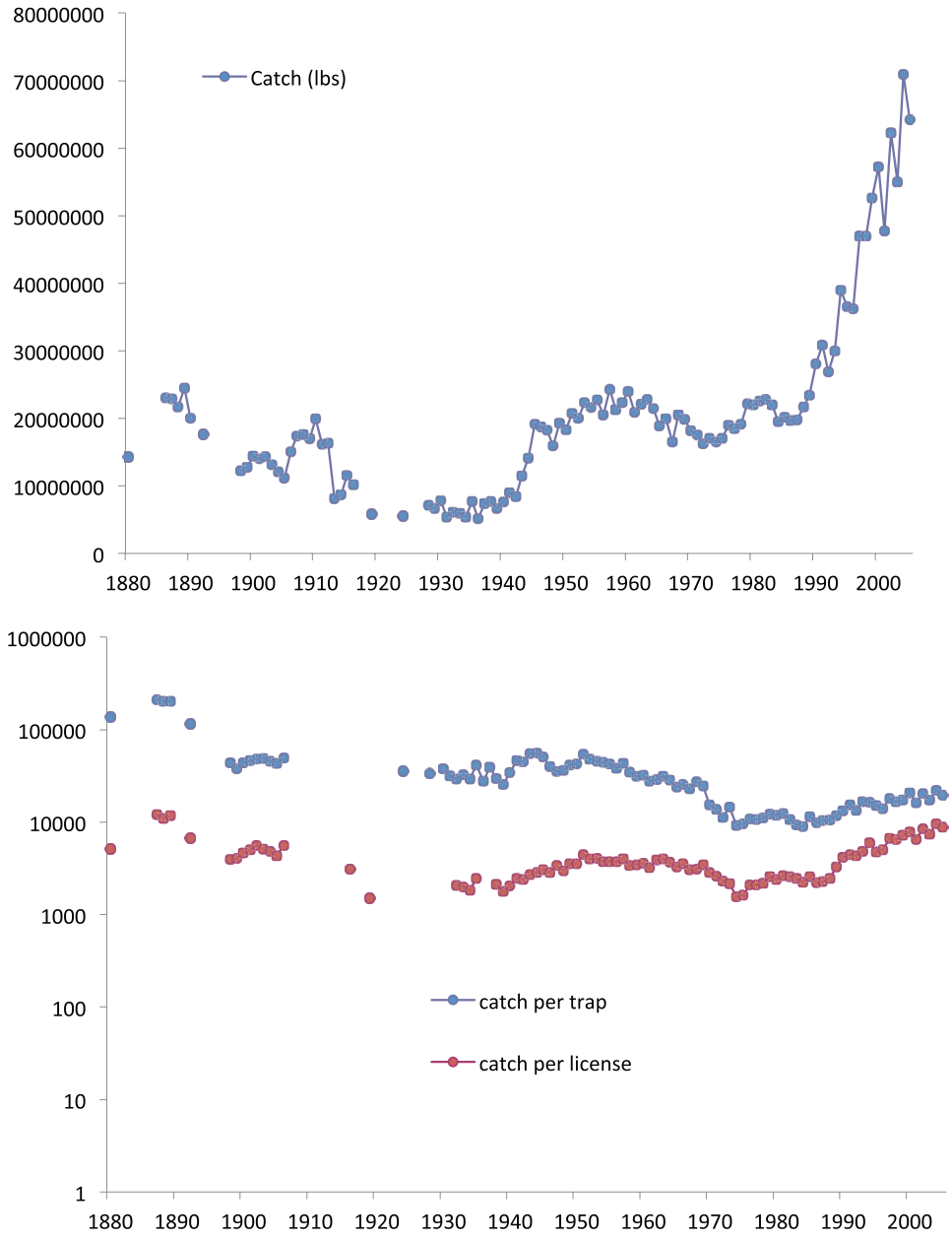

Figure 6.5: From top to bottom: (a) Lobster catch (in lbs) since 1880. (b) Lobster catch per trap and license based on data from the State of Maine historic data.

needed to catch each lobster. Thus, each fisher would be catching fewer lobsters in a given season. But if more fishers are fishing, the total catch could remain the same, or even increase, while the stock is being depleted. These are the classic symptoms of overharvesting. Figure 6.5 shows, in fact, that the catch per trap and catch per license are actually *increasing*. This suggests that the lobster fishery is not being overharvested, at least at the present moment.

Recently, in response to changes that were breaking down the informal harbor gang system, the state has formalized the system by dividing the state into zones with democratically elected councils. Each council has been given authority over rules that have principally local impacts—trap limits, days and times fished, and so forth. Interestingly, the formalization of local zones was followed almost immediately by the creation of an informal council of councils to address problems at a greater than local scale.

6.4 Forests

The final examples we will discuss are forests. More specifically we look at the most effective ways to protect forests. Due to the importance of forests for biodiversity, there has been an increasing focus on creating parks and protected areas. One key concern is whether these areas are best protected by putting a fence around them or allowing human populations to continue to occupy them and help with conservation efforts. A related concern is whether designated areas become "paper parks," i.e., areas set aside for protection on paper, but in practice, the lack of enforcement allows for a lot of poaching and illegal logging.

Ostrom and Nagendra (2006) discuss long-term studies of land use change to test which type of management is most effective. They compared governmental, community, and private forests and found that the particular form of ownership is not important for the condition of the forests as measured by the quality and size of the trees. More important is whether boundaries have been well established in the field and are considered legitimate and whether regular monitoring and enforcement of rules related to entry and use exist (Figure 6.6).

Whether the boundaries are considered legitimate depends on whether people have lived in the protected area before or if surrounding populations have used the resources over an extended period of time. If the boundaries are considered legitimate, how can they be monitored? For example, if indigenous populations are taken out of the protected areas (as has been the approach in several cases), one also loses potential monitoring capacity and it is not uncommon to see an increase in poaching in protected areas. Rather than relying in indigenous populations, perhaps paid guards are the answer? What are the incentives facing paid guards to monitor and enforce the rules? If guards are not paid well, they might be willing to accept bribes and not bother those who harvest illegally. This has also been observed frequently.

*Figure 6.6: Bicycles and trucks confiscated from people caught illegally removing large logs from the forests. Note the circular modification in the cycle frame (*Inset*) made to hold large logs of teak wood.*

Community forests (as opposed to those run by the state with paid monitoring and sanctioning)

can be effective since the population who benefits most from protecting the forests also monitors their use. In this case, because the cost of monitoring is aligned with its benefits, there is an incentive for high level monitoring effort, and those who are caught breaking the rules will experience social sanctions. On the other hand, community forests might be less effective in dealing with intrusion from outsiders due to lack of capacity and legal abilities to limit access (i.e., social sanctions won't be effective on outsiders). In this case, community forest managers need the assistance of the state. This is a clear example illustrating the importance of multilevel governance.

Governmental and privately owned forests can be effective if sufficient effort is made in enforcement. But they might be more prone to corrupt guards. Further, when local people do not feel a sense of ownership and participation in the process, they are less willing to assist with monitoring (hiring enough guards is prohibitively expensive). This will lead to a lack of sufficient eyes to monitor the use of the forests.

6.5 Critical reflections

There are many examples of self-organized governance of common-pool resources that have been successful over a long time. In the successful examples we see that local communities play an important role, often crafting the rules and monitoring and enforcing those rules.

6.6 Make yourself think

1. Do you make use of public parks? What is the state of the park? What are the rules, and how are they enforced?

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Key concepts

In this chapter we will:

- **Be introduced to design principles for effective institutions**
- **Learn about boundary rules, monitoring, graduated sanctions and input of local participants to collective-choice arrangements**
- **See how violations of design principles may lead to corruption and rent seeking**

7 — Design Principles to Sustain the Commons

Paper Parks

If so many hectares of land and ocean are designated as protected areas, why is there still so much overfishing, deforestation, species extinction and plundering of many natural resources? One of the problems is that areas might be protected on paper, in official legislation signed by officials in suits, but there are no effective institutional arrangements and associated infrastructure on the ground to support this legislation.

It is not uncommon that areas are officially protected but some high ranking officials have received access to harvest timber (such as is happening with the national parks in Sumatra). During his dictatorship in Indonesia, Suharto gave timber rights to powerful military leaders to "buy" their support for his regime. As a consequence the official national parks are now heavily deforested.

Figure 7.1: Illegal logging in West Kalimantan's Gunung Palung National Park. Hardwoods are being trafficked by a timber baron in the town of Ketapang.

How can we establish "parks in practice" instead of simply "parks on paper?"

7.1 Introduction

What is the best set of rules to govern the commons? This is the ultimate question asked by policy makers involved with managing common-pool resources and providing public infrastructure. Unfortunately, there is no such optimal set of rules. What we have learned over the years is that there are some "design principles" that explain why some communities are successful while others are not.

These design principles are based on a systematic study of many case studies of fisheries, irrigation, groundwater, and forestry systems. Some of these cases were discussed in the previous two chapters. Information was collected from each case study regarding the size and composition of the community, the formal rules and norms in use, how the system was monitored and by whom, the conflicts that arose, and how the resource system evolved over time.

Elinor Ostrom studied hundreds of these case studies in the 1980s and proposed the design principles in her classic 1990 book *Governing the Commons*. She initially focused on determining which rules were best but was unsuccessful in identifying a particular set of rules that were "best" in all circumstances. Instead she turned her efforts toward identifying eight underlying design principles

that characterized case studies of long-lasting common-pool resource systems. The design principles she identified were mostly met in these long-lasting systems, but were absent in those that collapsed.

The concept of eight design principles was an initial proposal in 1990. Twenty years later, an analysis of about 100 case-studies by Cox et al. (2010) provides evidence that the design principles hold up when challenged with data.

7.2 Institutional design principles

The design principles derived from case studies of long-lasting systems of common-pool resource governance:

1. **Clearly defined boundaries.** The boundaries of the resource system (e.g., irrigation system or fishery) and the individuals or households with rights to harvest resource units are clearly defined.
2. **Proportional equivalence between benefits and costs.** Rules specifying the amount of resource products that a user is allocated are related to local conditions and to rules requiring labor, materials, and/or money inputs.
3. **Collective-choice arrangements.** Many of the individuals affected by harvesting and protection rules are included in the group that can modify these rules.
4. **Monitoring.** Monitors, who actively audit biophysical conditions and user behavior, are at least partially accountable to the users and/or are the users themselves.
5. **Graduated sanctions.** Users who violate rules-in-use are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, from officials accountable to these users, or from both.
6. **Conflict-resolution mechanisms.** Users and their officials have rapid access to low-cost, local action situations to resolve conflict among users or between users and officials.
7. **Minimal recognition of rights to organize.** The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.

   For resources that are parts of larger systems:

8. **Nested enterprises.** Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

We will now look at each design principle in more detail. Although the design principles are intended for natural resources, we will illustrate their use with other kind of systems too.

7.3 Examples of design principles

7.3.1 Well-defined boundaries

The first principle relates to two types of boundaries: the boundaries of the resource system and the boundaries that determine which individuals or households have rights to harvest the resource. Having clear boundaries is critical to addressing the problem of free-riding. If there are clear boundaries indicating who can appropriate which resources, it will be clear who is following the rules or not when harvesting activities are observed.

These two types of boundaries are demonstrated in our roadway systems. Not having a valid drivers' license is a clear violation of a boundary rule of driving a car on the road. Roads themselves

benefit from clear demarcations on the road to define the lanes.

Such clear demarcations also help in sports to define the boundaries of the common space for competition. What would John McEnroe do if there were no clear lines on the tennis court? In many sports, players wear a uniform and a number that indicates that they are allowed to participate. You cannot just run in the New York marathon. You have to sign up and wear your start number and start in your assigned position. Also many internet services require that you register in order to be able to use those services. Watching a streaming Netflix movie in the U.S. is possible if you have paid your monthly fee, but it is not possible to do this on the same account on your laptop in China. The reason for this is that the rights for consuming the Netflix content are clearly defined for certain countries for which Netflix owns copyrights. When your laptop uses an IP address outside the U.S. it will not provide access to the content.

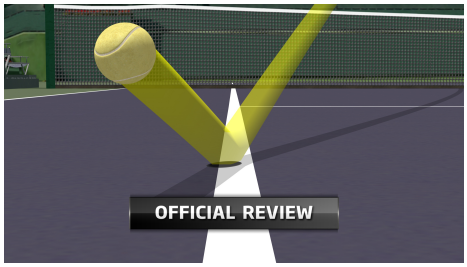

Figure 7.2: Nowadays technology helps to determine whether a tennis ball is in or out.

When resource users create boundaries, they can make use of the ecological context. For example, defining specific areas where one can harvest from the resource makes it easier to monitor and enforce.

Clearly defined boundaries are not enough for a successful institutional arrangement. One also needs to be able to defend boundaries against potential intruders. But the research shows that clearly defined boundaries are a prerequisite for success.

7.3.2 Proportional equivalence between benefits and costs

Do the rules allocate the benefits from the resource in proportion to the effort people put into harvesting and maintaining the resource? If some users get all the benefits and pay a small proportion of the costs, other users might not be willing to follow the rules over the long term. This design principle relates to fairness. Yet some inequality in the benefits people derive from the resource are acceptable provided the cost they bear in relation to the benefit is proportional. For instance, users may accept that the individuals who put a lot of effort into building an irrigation system get a better plot of land to grow his/her crops.

Salary levels are a typical topic of debate, especially in periods of economically challenging times. For the sustainability of an organization, it is not wise to lay off employers while the boss keeps her seven-figure salary. Similar levels of sacrifices are expected over the whole organization.

There are important differences between countries in how costs and benefits are defined. For example, because the labor market in the U.S. is more flexible it is easier to lose a job and there is only a limited safety net. Within Europe, social security provides a minimum level of income for people who have no job. How a society allocates its costs and benefits—as exemplified in their rules—is largely defined by prevailing social norms. Fairness within the U.S. relates to receiving benefits based on effort, while in Europe fairness relates to equality among people independent of effort. This is a gross simplification, but as the authors can attest—since both of us have lived on both continents—there are important differences in social norms that affect the rules on allocation of costs and benefits.

7.3.3 Collective-choice arrangements

People who are affected by institutional arrangements should have a way to participate in making and modifying the rules. Action situations where local resource users are able to devise rules are able to better tune those rules to local circumstances. Further, when participants make the rules together, they often receive more careful consideration by participants. When rules are viewed as imposed by an elite, participants are less likely to comply with them.

Universities typically include students in their governance systems, and sport federations have athletes on their boards. These are all ways to include relevant knowledge in the decision making process—the perspective of students and athletes—and increase the likelihood that the rules are accepted by the broader community.

In larger organizations, or even states, countries and the global community, the ability of people to participate in rule crafting seems difficult. Sometimes we may think the only thing we can do is to vote for who represents us in the decision-making process. One of the big challenges we face in modern times is the large scale of the communities we participate in.

7.3.4 Monitoring

How is monitoring of the rules organized? Effective monitoring is not only a matter of counting the number of guards, referees and policemen and making sure this number is high enough. The subtleties of what these monitors actually do to monitor and enforce the rules and the incentives they face are critical. If guards in a national park are not paid well, it is not surprising that they accept bribes to look the other way when poaching is happening. It is often more effective to have local people as monitors. This may assure conditionally-cooperative resource users that somebody is genuinely checking on the conformance of others to local rules. In urban areas neighbors sometimes organize themselves in a neighborhood watch instead of hiring security personel.

To understand whether monitoring will be effective, we need to understand what the incentives are for a monitor. Will a monitor be paid independent of whether rules are broken or not? Will a monitor be affected by rule breaking (are they a local resource user themselves). Will somebody notice whether the monitor is doing his or her job or not? If there is a lot of variation in harvest levels, people may not notice in the short run whether rules are broken or not.

Sometimes monitoring is so important for the functioning of the system that high investments are made in monitoring. In some highly productive fisheries in the Artic, each boat has an official of the federal agency NOAA (National Oceanic and Atmospheric Administration) on board. Does this sound outrageous? This is like having a police officer riding in every car to make sure drivers don't break the rules. What about all the official and unofficial referees (general public) during a football match?

7.3.5 Graduated sanctions

People make errors. When you make a mistake you get a warning. If you keep bullying a player on the other team you may receive a yellow card. And if you continue ignoring the rules you may get sent off the field with a red card or even be expelled from the league.

For many action situations there is a graduated sanctioning system. One reason is that rules are not always commonly understood or known, and getting a warning when a rule is broken may remind people of the actual rules in use. Another reason is the potentially high costs of strict enforcement. What would happen to a sport if there was strict enforcement of the rules? There are norms of fair play, and a tolerance of players exploring the boundaries of the formal rules.

7.3.6 Conflict-resolution mechanisms

The goal of conflict resolution mechanisms is to provide access to rapid, low-cost, local opportunities to resolve conflict among users or between users and officials. Rules, unlike laws of nature, have to be understood in order to be effective (the laws of nature function whether or not we understand them—right?). There are always situations in which participants can interpret a rule that they have jointly made in different ways. By devising simple, local mechanisms to get conflicts aired immediately and resolutions that are generally known and accepted in the community, the number of conflicts that reduce trust and cost time and money can be minimized. If individuals are going to follow rules over a long period of time, some mechanism for discussing and resolving what is or is not a rule infraction is quite necessary to the continuance of rule conformance itself. For example, within Wikipedia there can be eruptions of editing wars and designated editors can mediate between the different parties to resolve the conflict.

Not all disputes within the U.S. appear in front of the Supreme Court. Most conflicts can be resolved informally by having a good discussion in a neutral environment. By having a drink with your colleague or neighbor, you may discover that the conflict is mainly caused by a misunderstanding. When conflicts are not resolved in informal ways, more formal procedures are possible, such as through your home owners' association, your company, the court system, etc. The importance of cost effective conflict resolution cannot be understated. Consider the resources expended on litigation in the U.S. Litigating minor conflicts in hope of financial gain is enormously costly to society.

7.3.7 Minimal recognition of rights

When local users can organize themselves to craft their own rules, do national and local government entities recognize and respect these arrangements? The lobster fishers in Maine organized themselves in the 1920s and 1930s after the lobster population almost collapsed. The rules devised by these organizations were informal arrangements among fishers. In the 1990s the federal government wanted to reorganize fishery regulations along the east coast of the U.S. and have all fishers in all states comply with the same regulations. The well-functioning lobster fishery system would have been negatively affected by this, and significant efforts by fishers and scientists resulted in their informal arrangements receiving legal recognition, permitting them continue as they had within the framework of modern regulations.

7.3.8 Nested enterprises

When systems are larger, it may be necessary to have systems of governance at different levels. What might be needed is a "polycentric" (many centers of governance and authority) system. Every neighborhood may need to have policemen to patrol the streets, but not each neighborhood needs to have a crime lab. One crime lab for the whole city might be a better solution in terms of having the specific expertise available at a reasonable cost.

Polycentric systems emphasize approaching problems at the right level and ensuring that all parties with some control over outcomes (centers of power) are involved. This may mean that some collective action problems are addressed locally, while others are addressed at a regional or national level. For example, in resolving disputes on the use of water from the Colorado River, it is not productive to have Los Angeles and Phoenix debate this topic alone. Several states and the Bureau of Reclamation need to be involved in order to develop a meaningful plan for allocating the available water.

There are various challenges with polycentric systems. What is the right level of governance

for each problem? Some lower level communities might not be able to self-organize, or they may be dominated by local elites. How do higher-level authorities facilitate the local level governance systems to succeed?

In a polycentric system, some units are general-purpose governments while others may be highly specialized. Self-organized resource governance systems in such a system may be special districts, private associations, or parts of a local government. These highly specialized governance units are nested in several levels of general-purpose governments that provide civil, equity, as well as criminal courts.

A university is often organized as a polycentric system. Each department has a certain level of autonomy in offering courses. New courses can be offered, but to get them permanently on the books and count for college-wide credits, they have to be approved at the college level. Some basic requirements hold for all the majors, while the rest of the course work can be tailored to the specifics of the major.

Besides departments, there are specialized organizations and services such as fraternities and sororities, research institutes, financial aid offices, and libraries. Although there is a university president who oversees the whole university, most units have a lot of flexibility within the general constraints set by the higher levels of authority. If there is a lack of autonomy such that each decision at the local level requires approval from "above," a large organization will grind nearly to a halt because of the transaction costs associated with decision making and many decisions will be made by higher level officials without proper knowledge of the detailed practical problems associated with the decision.

7.4 Using design principles in practice

The design principles were originally proposed as hypotheses based on analysis of several case studies. In the more than 20 years since they were developed, they have held up to scrutiny. Although some people may interpret the design principles as blue prints for designing robust institutional arrangements, they are not. They are observed regularities derived by looking at cases after the fact. So how can we use the design principles in practice?

One way to use design principles is to translate them into questions concerning how to improve institutional arrangements for governing the commons. For example, for local resource users we can ask:

- How can we better define the boundaries of this resource and of the individuals who are using it so as to make clear who is authorized to harvest and where harvesting is authorized?
- How can we clarify the relationship between the benefits received and the contributions to the costs of sustaining this system?
- How can we enhance the participation of those involved in making key decisions about this system?
- Who is monitoring this system and do they face appropriate incentives given the challenge of monitoring?
- What are the sanctions we are authorizing and can they be adjusted so that someone who makes an error or a small rule infraction is sufficiently warned so as to ensure longer-term compliance without our trying to impose unrealistic sanctions?
- What local and regional mechanisms exist to resolve conflicts arising over the use of this resource?

For design principles seven and eight, questions need to be addressed at a higher level of governance.

- Are there functional and creative efforts by local appropriators to craft effective stewardship mechanisms for local resources that should be recognized?
- How do we create a multiple-layer, polycentric system that can be dynamic, adaptive, and effective over time?

These are not, of course, the only questions local resource users and officials should ask in an effective process of crafting institutional arrangements, but they can be thought of as a good beginning.

7.5 Threats to sustainable use of the commons

Even as we look carefully to the design principles for guidance, there are various threats to the sustainable use of common-pool resources. We list a number of them below based on what we have learned from many case studies.

7.5.1 Rapid exogenous changes

Rapid changes in technology or population numbers can become a challenge to effective governance of the commons. A new technology that enables fishers to catch more fish with the same amount of effort, may render rules on where and when to fish useless unless restrictions on gear are implemented. The provision of music, movies and books has experienced many challenges during the last few decades with the emergence of new physical devices to digital files. These challenges have caused the need for change in the original business structure of creative activities in order to remain viable. A musician cannot depend on the sales of music records anymore, but must find other ways to earn revenues from his or her creations.

7.5.2 Translation failures

Informal arrangements can be translated into official rules. For example, when writing the bylaws of a homeowners association the rules are often based on informal practices. Over time the reasons *why* some formal rules are written in the books may be lost, which may lead to problems.

For example, when a simple majority rule is used to make decisions, one can push forward with important decisions when the minimum number required is reached, but this might not be best for the viability of the community. A slight majority means that almost as many members of the community oppose the decision. Leaders who rely on minimal majorities for too many decisions may find themselves having to use coercion and/or corruption, rather than general agreement, to keep themselves in power.

7.5.3 Blueprint thinking

The fact that some rules work out well in one action situation does not mean that those same rules will work well for other situations. The rules and regulations for urban planning in Boston might not work well in Phoenix given the many differences in the biophysical and social context. Rules of the game of ice hockey may not work well for field hockey. Nonetheless, we see blueprint thinking frequently, especially when large organizations implement many projects, as is the case in development agencies. The World Bank may implement projects on community development

in many places in the world, but requires each project to use the same blueprint policies to receive funding.

7.5.4 Corruption and rent seeking

When individuals in power have the opportunity to allocate resources, there is always the possibility of corruption. In these situations various actors may collaborate to harvest subsidies or large infrastructure investments. When a bridge needs to be built, will the money be spent to build it according to the specifications, or can the inspector be bought off to save on expensive, high quality construction materials?

7.5.5 Lack of large-scale supportive institutions

Small-scale communities can be very effective in self-organizing and sustaining their shared resources but will eventually experience challenges in the long term if they do not have the support of larger-scale institutions. For example, when efforts are coordinated at a large scale, scientific information can be collected and analyzed with expertise and resources that are not possible at the small-scale (it is difficult to build a particle accelerator by yourself). Farmers, for example, may receive help from highly trained professionals on new technologies and methods. Agricultural extension agencies provide a supportive role in disseminating knowledge, information and experience that farmers would not have the time to gather as individuals working alone.

7.6 Critical reflections

Based on the analysis of many case studies of fisheries, forestry, irrigation systems and other long-lasting social-ecological systems, design principles can be identified. Those design principles are not blueprints for design but are guiding principles to analyze institutional arrangements and help researchers and practitioners to ask appropriate questions to improve the governance of the commons as needed.

7.7 Make yourself think

1. What are examples of boundaries that are not clearly defined?
2. Neighborhood watch programs are an example of self-monitoring. What are the pros and cons of such programs? How about neighborhood Home Owners Associations (HOA's)? Have you ever heard someone say about the new house they bought "Well, the good thing is that there is NO HOA".
3. When economic times are tough, politicians often recommend centralization of government function to save money. Why is centralization of governance structures in cities not necessarily an effective way to save monetary resources?

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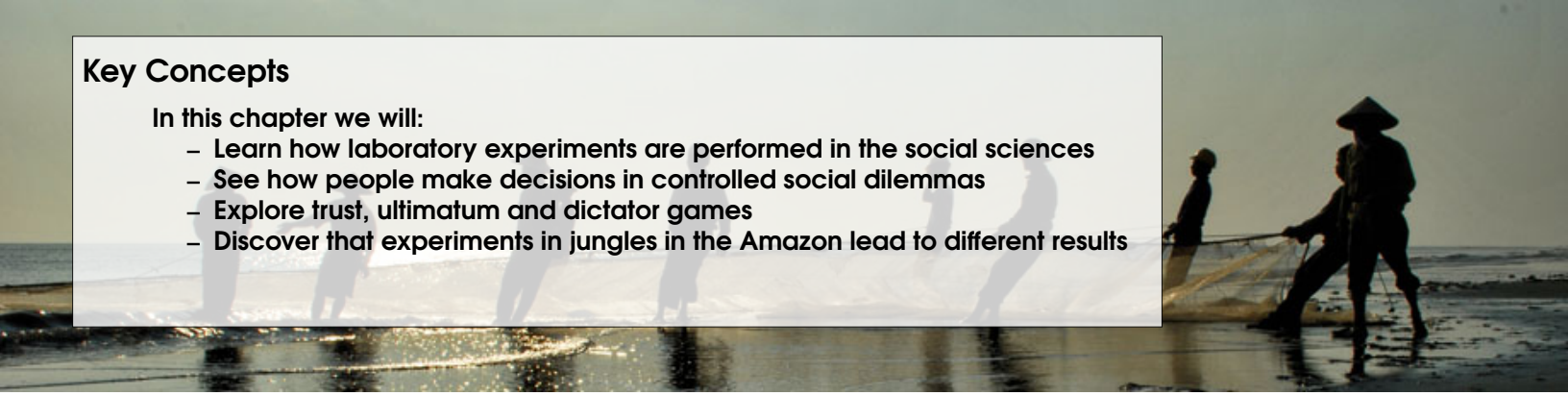
Part III

Human Behavior



Key Concepts

In this chapter we will:

- **Learn how laboratory experiments are performed in the social sciences**
- **See how people make decisions in controlled social dilemmas**
- **Explore trust, ultimatum and dictator games**
- **Discover that experiments in jungles in the Amazon lead to different results**

8 — Social Dilemmas in the Laboratory

8.1 Experiments in social science

In previous chapters you have learned about the structure of action situations. In action arenas individuals interact in action situations. Recall our example of the chess game as an action situation that becomes an action arena when two people sit down to play. Every chess game is played the same way—i.e., the structure of the action situation does not change over time. But the outcome of every chess match is different. The decisions the players make in the action arena *animate* the chess action situation. But how do people make decisions in such situations? In Chapter 4 we assumed that decisions were made as if people behave selfishly and rationally. This chapter will show that this is not the case in practice.

One of the ways to study how people make decisions in action situations is through the use of experiments. There are many types of experiments but in this chapter we focus mainly on controlled experiments in laboratory situations. Experiments are an excellent way to connect action situations with social dilemmas. When we design an experiment, we have to be explicit about the structure of the action situation. We can construct specific action situations that mimic social dilemmas that people encounter in the real world. We can then systematically vary particular characteristics of the action situation to determine how changing such characteristics affects peoples' decisions. Indeed, as we discuss various experiments below, you will see how changes in the action situation affect the way people make decisions. Finally, data from experiments can be compared to observations from case studies.

We begin by clarifying what we mean by laboratory experiments in the social sciences. In a typical experiment, the experimenter creates a situation where a number of participants make decisions in a controlled setting. Often experiments are performed at universities using undergraduate students as participants. Maybe you have participated in experiments by this point in your academic career?

Figure 8.1: Set up of an experimental laboratory.

Participants voluntarily consent to take part in an experiment. They receive instructions on the actions that can be taken and the consequences of these actions that eventually result in monetary rewards. Decisions are made in private. In a typical lab, participants sit at a desk with a computer, surrounded

by partitions that prohibit them from talking with others or viewing other participants' computer screens (see Figure 8.1).

The experiments are designed and performed to test scientific hypotheses. As you will see in this chapter, the participants in the experiments make decisions in an artificial setting (controlled action situation). The goal of an experiment is not to recreate reality, but to focus on a specific situation A and test the decisions people make compared to situation B.

For example, in Chapter 4 we discussed the prisoner's dilemma. We considered what the outcomes would be *in theory* for selfish rational individuals (they will not cooperate). But what will real people actually do? What would you do? Since the 1950s, many experiments have been performed with the prisoner's dilemma action situation. Typically we see that 50% of the people cooperate in the prisoner's dilemma experiment (Sally, 1995). This is considerably different from the theoretical prediction that 0% would cooperate.

In the remainder of this chapter we will explore some classic social dilemma experiments. For each of these experiments we will first analyze the action situation to determine what outcomes theory would predict for selfish rational actors and then discuss actual empirical outcomes. We end the chapter by discussing examples of these experiments that have been replicated by anthropologists with tribes in the jungle.

8.2 The trust game

We begin with the so-called "trust game" (Figure 8.2). This two-person game was developed by Joyce Berg, John Dickhaut and Kevin McCabe in 1995 to focus on the factors that affect the likelihood that an individual will take an action whose outcome may be potentially costly when that outcome depends on actions of a second individual. In simple terms, this action requires that the individual places trust in a second individual. Think about giving somebody your credit card information. Can you trust that the other person will not misuse this information? The more people trust each other, the more cooperation is possible. Of course, if people easily trust each other, they are also easy victims of selfish rational individuals who "free ride" on the trust of others.

Figure 8.2: A physical trust game. Will they catch him?

Using the terminology of the action situation, the simplest baseline trust game is composed of the following elements:

1. *Participants*. Two persons play the game.
2. *Positions*. The two positions are player 1 (investor) and player 2 (trustee).
3. *Actions*. Player 1 is given 10 tokens at the beginning of the game. Player 1 then has the choice of how many of those 10 tokens to keep and how many to "send" to player 2. Choosing to "send" tokens to player 2 has the impact of increasing the value of the tokens. In typical trust experiments, the number of tokens sent by player 1 is doubled or tripled (see point 5 for an example). After the experimenter has increased the amount that player 1 has sent, this amount is sent on to player 2. Once player 2 has received this amount, player 2 makes a decision.

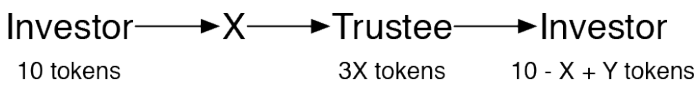


Figure 8.3: Trust game with the payoffs used by Berg et al.

Player 2 has to decide on the number of tokens to return to player 1.

4. *Outcomes*. The outcomes are the size of the funds allocated to the two persons in light of the decisions they have made.
5. *Action-outcome linkages*. The amount invested by player 1 in player 2 earns a rate of return (supplied by the experimenter) of 1 + r. If r = 2, then if player 1 gives 10 tokens to player 2, player 2 receives 30 tokens. If player 1 gives 2 tokens, player 2 receives 6 (= 2 * 3) tokens.
6. *Information*. Both players are informed of the complete range of possibilities and that their own identity will remain anonymous to the other player (and to the experimenter if a double blind experiment is performed).
7. *Potential payoffs*. The payoffs are affected by the rate of return (1 + r). In most trust experiments, r is assumed to be 2. This means that the amount that player 1 sends to player 2 is tripled by the experimenter. The payoff to player 1 is (10 - X) + Y where Y is the number of tokens that player 2 returns to player 1. The payoff for player 2 is (1 + r)*X - Y (note if X is zero, player two's payoff is zero).

If this game seems a bit strange to you, consider for a moment your bank account. Your relationship with your bank represents an action situation very similar to this game. Namely, you, player 1, invest your money in the bank (put it in a savings account or "send" it to the bank). The bank, player 2, may or may not give you your money plus interest, i.e., 1 + r times what you gave the bank back.

A self-interested trustee (player 2) wanting to maximize returns (behaving as *homo economicus*) would return zero to the investor (player 1). If the investor expects this, no funds will be invested (transferred to the trustee) in the first place. Let's reconsider the bank example again. If your bank wants to maximize its returns, and only plays with you once, it will just keep your money. If you know that this is a possibility, you won't give them your money. Establishing trust between you and your bank is thus essential for potentially valuable transactions to take place. Loss of this trust causes runs on banks and precipitated such catastrophic events as the great depression after the crash of the New York Stock Exchange in 1929.

The baseline trust game is barren of many of the social factors that are thought to affect trust. The players are strangers and do not even see one another. There is no way that they can establish a link to one another through making promises or the like. The trust game is similar in structure to a prisoner's dilemma if players make decisions sequentially. The baseline game represents a situation requiring trust in about as pristine a form as one can imagine.

Figure 8.3 shows the trust game once more, using r equal to 2. The investor gives X tokens to the trustee who then earns 3X - Y where Y is the amount returned by the trustee to the investor. The investor thus earns 10 - X + Y. If the investor does not trust the trustee she may choose to invest 0, i.e., set X = 0. As a result the trustee will not receive anything.

When the first experiments were performed by Berg and her colleagues, they used a double-blind experimental protocol. In this protocol the experimenter will not know the identity of the participants. Each token in the game was worth one dollar. From the 32 persons who were in the position of

investor (player 1), 30 sent money ($5.16 of the $10 on average) to the trustee (player 2). Of the 30 subjects in the position of trustee, 18 returned more than $1.00 ($4.66 on average) and one-third of them sent more funds to the investor than the investor sent them (before being multiplied by three). On average those investors who sent $5.00 or more received an average return in excess of the amount they sent. It was those investors sending less than $5.00 who received a negative net-average return. In other words, those investors who trusted their counterparts the most were the ones who left the game with more wealth than those who were less trusting.

Although this experimental design of the trust game is simple, it captures the essence of trusting and reciprocal behavior so effectively that it has been replicated and extended in many different settings and countries.

Some of you may be surprised at the high levels of trust exhibited in this experiment. The common theory used to make predictions in this action situation assumes selfish rational behavior and predicts no investment. The investor is not expected to trust an unknown stranger enough to send *any* funds. The empirical data challenges the conventional theory.

8.3 How people make decisions

We have mentioned that theory predicts that participants will act as selfish rational human beings when faced with a decision that involves costs and benefits to themselves. Yet we have just discussed a set of experiments that show that people do not make decisions in that way. So, why do we make these assumptions? These assumptions relate to *rational choice theory*, an important theory in the social sciences. Rational choice theory is a framework for understanding economic and social behavior (we define it more precisely below). It has proven to be valuable in predicting human behavior in stable, competitive market settings. In stable and repetitive settings, individuals are able to learn about the full, relevant structure of the situation and attach preferences to actions and outcomes.

Predictions from these models are empirically supported at an aggregate level in open competitive market settings and at an individual level in carefully designed experimental settings of competitive market situations (see the work of Nobel Laureate Vernon Smith). What are the assumptions of rational choice theory? They are:

1. Individuals possess as much *information* about the structure of a situation as is contained in the situation itself. That is, they have perfect information about the world around them and the situation they are in.
2. Individuals assign a complete and consistent, internal *valuation* to outcomes that is a monotonic function of an individual's own net external payoff. Put simply, this means that individuals will always prefer more units of a product to less units. Furthermore, if an individual likes product A more than product B and product B more than product C, then this individual will also like product A more than product C.
3. After making a complete analysis of the situation, individuals choose an action in light of their resources to *maximize* expected material net benefits to themselves given what they expect others to do.

We will call participants whose behavior can be predicted by these three assumptions *rational egoists*. When we study institutions, individuals in many situations do not meet the specific assumptions of rational choice theory. The rational egoist might be a good starting point to predict

human social and economic behavior, but we know it cannot explain all observed behavior. Unfortunately, there is not a widely accepted alternative theory. Such a theory should include assumptions concerning

1. the way that participants acquire, process, represent, retain, and use *information*;
2. the *valuation* that participants assign to actions and outcomes, especially the outcomes that others experience; and
3. the processes (heuristics) that participants use for *selecting* particular actions or strategic claims of actions in light of their resources.

Given the many different assumptions that are involved in a more mature theory of human behavior, a more realistic theory would not be as simple, elegant and decisive as rational choice theory. We cannot discuss all the possible assumptions of this enormous body of literature that could be involved. We do, however, discuss some of the most important ones.

1. There is increasing evidence that a crucial element in decision making is the evaluation of the outcomes for the decision-maker *and* others whom their decisions might affect. Many people value fairness and equity and prefer a more equal distribution of payoffs rather than maximizing their own earnings. Why people have these values is not clear. An important factor is the social norms people acquire during their lifetime regarding what they are supposed to do. Not surprisingly we find norms like "Do unto others as you would have them do unto you" that serve as guiding principles in educating young people in how to behave in their interactions with others.

> *"Love your neighbor as yourself"*
> *"Do unto others as you would have them do unto you"*

2. One of the main strategies that we find people use is conditional cooperation. People cooperate if others do so too. This means that in repeated situations involving social dilemmas, people may adjust their decisions if they observe others are more or less cooperative than they had expected. "One bad apple can spoil the whole bunch" is a common saying that illustrates the principle that one persistent defector can trigger others to change to defection too.
3. People have incomplete information and an incomplete understanding of the world around them. Humans develop mental models as a consequence of experiences and information they have received. As such, mental models are a product of experiences during childhood, the culture people come from, and the ability to process the information received through life experiences. In an action situation participants have incomplete information but use their mental models to infer what others will do, what others will think about them, whether others can be trusted, and what the payoff matrix means for them. Communication may play an important role because communication enables people to share information to update the expectations they have about each other.
4. What is clear from the empirical analysis of many social dilemma experiments is that there is not one method by which people make decisions. We can detect various strategies, and allowing for heterogeneity of strategies across individuals is crucial in explaining observations from experiments. If you are in a social dilemma with people you know very well, it is easier

to judge what they will do and vice versa. Under these circumstances, it is more common that groups will cooperate.

8.4 Ultimatum and dictator games

We will now consider two other games that provide additional insights into how people make decisions in social dilemmas. Both games are called one-shot games, meaning that they are played for only one round. The first game is the ultimatum game, and the second game is called the dictator game.

In the ultimatum game there are two players who interact anonymously, without communication and only once. The first player receives a sum of money (called the "endowment") and then has the following decision to make: "decide how to share the endowment you received between you and the other person." It is important to know that there is no communication and the participants do not know each other's identity and will never know each other's identity. The offer the first player makes to the second player can be accepted or declined by the second player. If the second player declines the offer, both players receive nothing. If the second player accepts the offer, the endowment is divided the way the first player proposed.

Suppose that player 1 receives 10 one-dollar bills. A selfish rational player would accept any offer. Player 1, thinking that player 2 would behave selfishly and rationally would therefore offer a minimum amount—say one dollar to player 2. Player 2, being rational would accept 1 dollar, because 1 is better than 0, which is the only other available option (i.e., decline the offer). The ultimatum dilemma was proposed in 1982 by Werner Güth and his colleagues and today is a frequently used experimental design. Experiments on ultimatum games have been performed all around the world. In many cultures, people offer a fair split (e.g., 50:50), and offers of less than 20% are often rejected. The persistence of this result indicates that, in general, people do not make decisions as the rational egoist model would predict.

A common explanation of these empirical findings is that people evaluate aspects of the potential outcomes of their decisions other than monetary benefits, such as the relative distribution of benefits between the player herself and others. Let's now consider the ultimatum and dictator game using the terminology of the action situation:

1. *Participants*. Two persons play the game.
2. *Positions*. The two positions are participant 1 and participant 2.
3. *Actions*. Participant 1 is given X at the beginning of the game. Participant 1 then decides how much to keep and how much to offer participant 2. In the ultimatum game participant 2 can choose to decline the offer, which results in zero earnings for both participants. In the dictator game participant 2 does not make a decision.
4. *Outcomes*. The potential outcomes are the different allocations of the endowment to the two persons in light of the decisions they have made.
5. *Action-outcome linkages*. The amount offered by participant 1 affects whether participant 2 will accept the offer in the ultimatum game. In the dictator game, the amount offered by participant 1 affects only the final allocation.
6. *Information*. Both players are told the full tree of possibilities and that their own identity will remain anonymous to the other player.
7. *Potential payoffs*. The payoffs are affected by the decision of participant 1, and in the ultimatum

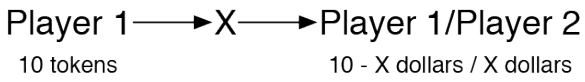


Figure 8.4: Dictator game.

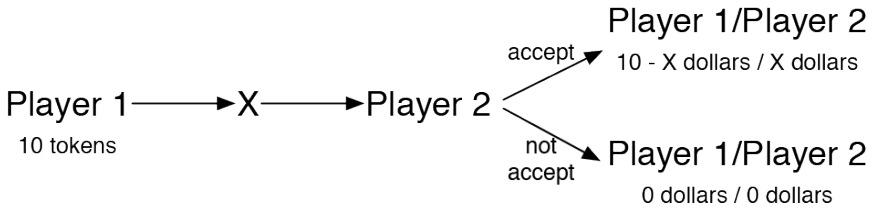


Figure 8.5: Ultimatum game.

game whether participant 2 will accept the offer or not.

The dictator game is described schematically in Figure 8.4. Player 1 makes a decision about how much (denoted by "X") to give to player 2. Once player 1 makes the decision that marks the end of the game. Player 2 does not make a decision. Figure 8.5 shows the ultimatum game. In this game, player 2 can decide to accept the offer or not. If accepted, the distribution of the endowment is the same as proposed by player 1, otherwise both players have zero dollars.

8.5 Bringing the lab to the field

How general are the findings of the experiments performed with undergraduate students at American and European universities? Do these decisions represent the entire population or are they just artifacts of a western cultural heritage? Anthropologist Joseph Henrich started to perform ultimatum experiments in the Amazon with communities who have not had many interactions with western societies (Figure 8.6). Doing such experiments is very challenging. One has to work with a population who might not read or write, who may not use money, or possibly speak a rare language. Furthermore, field experiments are not conducive to computer-based experiments like those performed in laboratories as discussed previously.

Figure 8.6: Joseph Henrich in the field.

In the field, experiments are translated into the local language. If money is not relevant to the community (there is nothing to spend it on), rewards will be given in physical objects such as food items. Experiments are performed with pencil and paper, or physical objects. People make decisions one at the time in private, and only later the decisions of player 1 are matched with a randomly drawn player 2.

Henrich and colleagues used the same experimental design in 15 places around the world and found a much wider diversity of decisions than earlier experiments that were held with people in modern market economies. Some communities had a much lower level of offers in the ultimatum game, and accepted a much lower level of offers (Figure 8.7). For example, the Machiguanga people from Peru made decisions in the ultimatum game most in line with the prediction of selfish rational

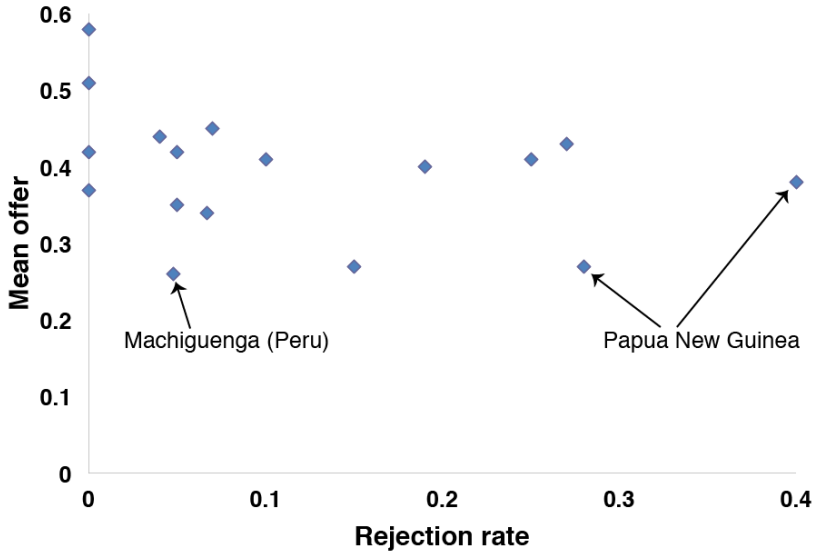


Figure 8.7: Mean offer versus rejection rate in ultimatum game (adapted from Henrich et al. 2001).

persons. Others, such as the Lamelara in Indonesia offer more than 50% and do not reject any offer. In Papua New Guinea, experiments in two communities led to a very high rejection rate. Often participants rejected high offers. A possible explanation for this is that their custom regarding gift giving is that if one receives a gift one *must* give a gift in return. Although they did not know the identity of the other player, participants in these experiments still did not want to be obligated to give a gift back.

The large variation in the data is, to some extent, related to the type of activities the communities performed in their daily lives, ranging from hunting and gathering, to fishing, farming, and pastoralism. Having said that, in general the populations' familiarity with a market exchange affected the level of the offerings more strongly that did other factors. In 2010, Henrich et al. (2010) published a follow-up study where market integration was measured as the percentage of calories purchased on the market (Figure 8.8). In the U.S. such a percentage is about 100 percent, while some hunter-gatherer groups where completely self-sufficient and purchased 0% of their calories from the market. Henrich and colleagues found that the more communities were integrated with the market, the more they offered in dictator games.

Do markets lead to cooperation? The publication of the initial results led to a huge controversy. The results seem to suggest that capitalism can lead to cooperative behavior. This is not the right conclusion to make. What the results indicate is that in societies where it is common to exchange goods with strangers, something we do in a market-based society, people become more comfortable cooperating with strangers. For those who gather and hunt their own food and never have any interaction with people beyond their extended family, participating in an experiment in which they make a decision with an unknown other person in the broader community is a strange experience. Since this is an uncommon experience, participants without market experience may not be generous to the other participant.

In market-based societies there is a strong norm of fairness. But what about the news reports of bankers receiving exorbitant bonuses during the most recent financial crisis? The protests that

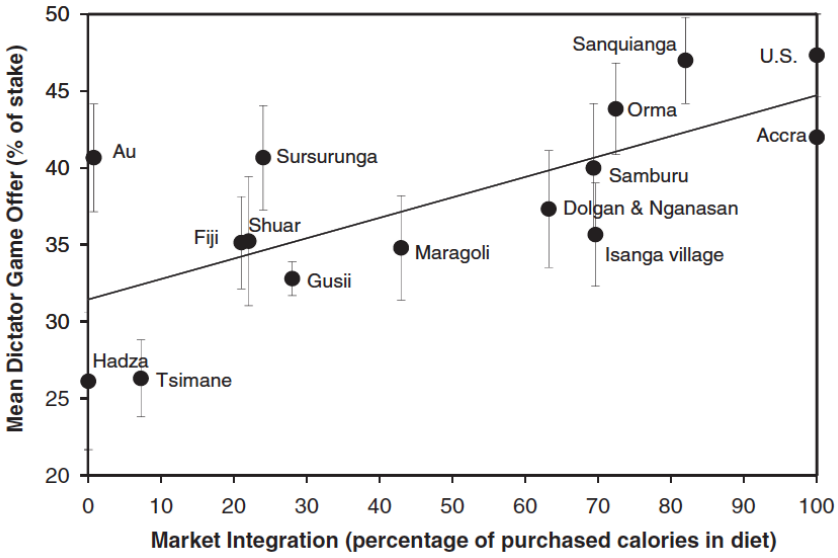


Figure 8.8: Mean dictator game offers for each population plotted against mean value of market integration (Henrich et al. 2010).

erupted in response to this greedy behavior suggests that there is a strong sense of fairness. The fact that some do not follow the social norms has also to do with power inequality. In the experiments all participants are randomly allocated to player 1 and player 2. Since players do not know who their partner is, reputation and power differences do not have a major effect on the experimental results. If players did meet face to face, the outcomes of the experiment would no doubt be considerably different.

8.6 Critical reflections

Three social-dilemma **experiments** were introduced in this chapter: the **trust game**, the **dictator game**, and the **ultimatum game**. These games can be analyzed using the **action situation** framework. Experiments with these games in the lab and the field show that theoretical predictions that people will act as **rational egoists** are falsified. There is not yet a general alternative theory of decision making, but it is clear that most humans take into consideration the well-being of others (including strangers) when making decisions. We also discussed how experiments can be used to explore how the level of cooperative behavior is influenced by **social context** such as the level of market integration.

8.7 Make yourself think

1. What do you expect will happen if two bankers play the ultimatum game?
2. And what if an ultimatum game is played where members of the 1% are player 1 and members of the 99% are player 2?
3. Have you ever experienced a situation similar to the trust game?

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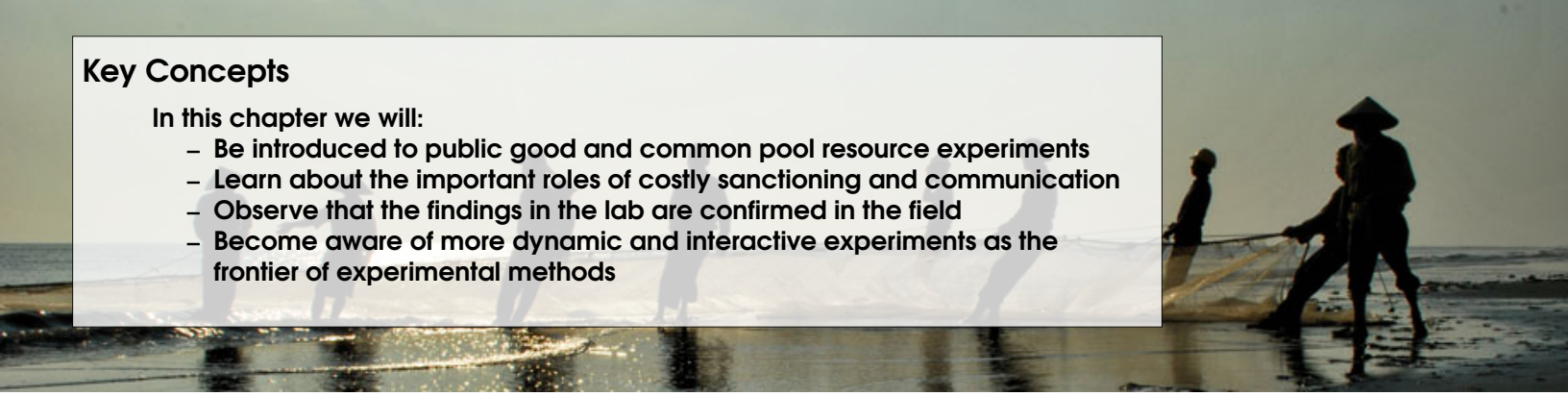

Key Concepts

In this chapter we will:

- **Be introduced to public good and common pool resource experiments**
- **Learn about the important roles of costly sanctioning and communication**
- **Observe that the findings in the lab are confirmed in the field**
- **Become aware of more dynamic and interactive experiments as the frontier of experimental methods**

9 — Self-governance in the Laboratory

Learning from Peasants

During field work in Nepal in the 1980s Elinor Ostrom learned from interviews that farmers monitored each other's water withdrawals and contributions to maintenance. She also observed a dramatic event in which a group of farmers dropped their work to repair a mud-based canal from which a farmer was withdrawing water illegally.

Back in the U.S. Ostrom discussed these events with colleagues in economics. The initial response from the economists was that it was illogical to invest so much time in monitoring and enforcement. Maybe peasants would do this, they argued, but people with higher levels of formal education would never do this self-policing. As a result, new experiments were designed where participants could give up earnings to reduce the earnings of others. Although it is irrational for rational egoists to do so, actual participants did use this costly sanctioning. The important role of costly sanctioning is now well established.

9.1 Introduction

In the last chapter we explored social dilemmas involving only two players, playing one time only, and making very simple decisions. In this chapter we will look at more complex experiments involving public goods and common-pool resources. These dilemmas are the main focus of this course. In Chapter 4 we saw that these types of goods are difficult to exclude others from using. Public goods, like Wikipedia, national defense, public radio and clean air can be used by everybody, yet there are costs to individuals to invest in the provision of public goods. Hence we can expect an under-provision of public goods. With experiments we can test the assumption that public goods cannot be provided voluntarily. The same is true for common pool resources, which are vulnerable to overharvesting.

9.2 Common-pool resource action situations

In Chapter 4 we introduced the idea that with common-pool resources, it is difficult to exclude or limit other users' consumption of the resource and each person's consumption of the resource reduces the availability for others. We will now discuss how the basic dilemma in a common-pool resource setting can be translated into an action situation that we will subsequently use in a laboratory experiment.

For ethical reasons, we cannot do experiments with real resources. Therefore we create an artificial resource. Participants in the experiments earn a certain amount of money based on their

decisions, just as in the simple ultimatum and dictator games discussed in the last chapter. Below we introduce a model that demonstrates that when more people harvest from the common-pool resource, less money is earned per unit of effort by each individual. In the experiments, participants receive tables in which they see the consequences of their decisions, given the decisions others make.

We need to start with a static, baseline situation that is as simple as possible without losing crucial aspects of the problems that real appropriators face in the field. This static, baseline situation is composed of:

1. *Participants.* A set of n individuals.
2. *Positions*. No differentiation exists in the positions these participants hold relevant to the common-pool resource. In other words, there is only one position of resource appropriator.
3. *Actions*. Appropriators must decide how to allocate tokens assigned to them in each time period. Basically, one can think of these appropriators as being "endowed" with a number of tokens, e, which they are free to allocate in any proportion during each time period to each of the two activities. To simplify the problem, we posit that all appropriators have the same endowment (just as we all have only twenty-four hours per day), and face the same outside opportunity. Thus, each round they have to decide how much of their endowment to devote to appropriation from the common-pool resource or in gaining returns from an outside activity. For example, if each appropriator is given 10 tokens (e.g., 10 hours of labor), they can use 5 hours to go fishing (use the common-pool resource) and 5 hours working for a fixed wage.
4. *Outcomes*. The action they take affects the amount of resource units that can be appropriated from the common-pool resource or returns earned from the outside option.
5. *Action-outcome linkages*. Here we use a mathematical function to translate the actions of all the appropriators into outcomes. While these functions are in reality frequently affected by many variables in addition to the actions of individuals, we will consider only simple, deterministic relationships between appropriation actions and their effects on the resource in the baseline setting. For wage labor, the relationship (function) is simple: the amount of time allocated to wage labor is simply multiplied by the standard wage. The resource function is a concave function, F, which depends on the number of tokens, x, invested in harvesting the common-pool resources.
6. Initially, the sum of all of the individuals' harvesting actions, Σx, generates better outcomes than the safe investment in wage labor. If the appropriators decide to allocate a sufficiently large amount of their available assets (e.g., time) to harvesting the common-pool resource, the outcome they receive is less than the alternative. In other words, allocating too many assets to harvesting the common-pool resource is counter-productive.
7. *Information*. As an initial information condition (because of the instructions that are carefully given to all participants), we assume that appropriators know the shape of the function linking actions to outcomes and know that they are symmetric in their access to assets and opportunities. Information about outcomes is generated after each decision round is completed. Appropriators may not communicate with one another. It is assumed that each appropriator will assume that all other appropriators are rational actors and will adopt the "best response" as their own actions. If all players do, in fact, act as rational egoists, the best response functions should lead all appropriators to overharvest from the resource.
8. *Potential payoffs*. Payoff functions specify the value of the wage rate and the value of the resource units obtained from the common-pool resource. Specifically, the payoff to an appropriator is the payoff from wage labor plus the payoff from using the common-pool

resource. If we call the total endowment of tokens (i.e., units of labor) e, and the wage ω, then the payoff function is given by

$$\begin{array}{ll} e \cdot \omega & \text{if } x_i = 0 \\ \omega \cdot (e - x_i) + (x_i / \sum x_i) \cdot F(\sum x_i) & \text{if } x_i > 0 \end{array} \tag{9.1}$$

Basically, if appropriators put all of the assets into the fixed wage option, they receive a certain monetary return equal to the amount of their endowment times, an unchanging rate of return (ω). If appropriators put some of their endowed assets into wage labor and the rest in harvesting from the common-pool resource, they get part of their return from the wage labor ($\omega \cdot (e - x_i)$) and the rest from their proportional harvest of the common-pool resource as determined by function F.

Suppose participants receive 10 tokens (e.g., 10 hours of labor) each round (a round could represent a day, so setting e equal to 10 is equivalent to allowing the players to work 10 hours per day.) What share should we expect will be invested into the common-pool resource that maximizes income of each player in the group? The function F() is depicted in Figure 9.1 for an experiment with 8 participants. You can see that as more people invest in harvesting the common-pool resource F will start declining at a certain point (blue line). Since F is the earnings people get from harvesting from the common-pool resource, it follows that at a certain point participants will get less returns if they keep on investing their effort in harvesting the common resource. We use a value of 0.05 for ω, which means that participants earned 5 real cents for each token used for wage labor.

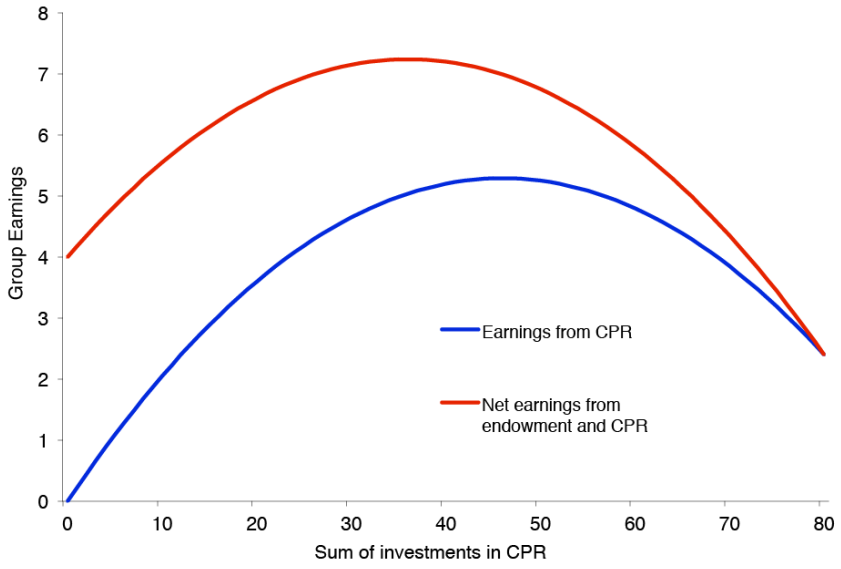

Figure 9.1: The value of the function F () for different levels of Σx is depicted as the blue line. The red line is the value of F plus $\omega \cdot (10 \cdot e - \Sigma x)$.

If the group could agree to work together, what would be the best thing to do? From Figure 9.1 it is clear that the best earning from the groups perspective would be to invest a total of around 40 tokens. At that point the red line, the net earnings, reaches the maximum level. To be precise, we can calculate that the group earnings are maximal when the total investment is 36 tokens. This is an

average of 4.5 tokens per person. In that case the total earnings would be 7.24 units, which is 0.91 units per person. At the end of the experiment, the participants are paid in cash based on their payoff "units." Often, the units are cents. So after playing 20 rounds and earning 0.91 tokens per round as in the example above, the participant would earn 20 x \$0.91 = \$18.20.

However, from an individual perspective, the problem looks different. If others do not appropriate from the common-pool resource, a maximum harvesting investment of 10 will be most productive. So if you invest labor in harvesting and no one else does, you will do well. But if everybody thinks in this way, the total level of harvesting goes up. When each participant invests 8 tokens in harvesting there is no opportunity for individuals to improve their earnings. Note that the individual earnings in this case is a little above 0.5 which is substantially lower than the earnings of 0.91 realized if everybody had invested an average of 4.5 units of labor in the common-pool resource and 5.5 units in wage labor. However, if people are rational egoists, we expect they invest 8 tokens per person. Like the tragedy of the commons, people keep adding sheep as long as the individual benefits are larger than the costs that are shared by everyone else.

We will now discuss some of the results from the common-pool resource (CPR) experiments that have been conducted using this action situation. Participants know that they are participating in an experiment that will not take more than 2 hours. The number of rounds in each experiment varies between 20 and 30. In addition to being told the payoff function specifically, participants were provided with look-up tables that eased their task of determining outcomes depending on their own and others' decisions.

In the baseline experiments, the actual average investment level in the CPR is around 8 tokens, as predicted if we assume all players act as rational egoist. Figure 9.2 shows that the investment level stays the same over 30 rounds. However, although the average investment is 8 tokens, most people don't invest 8 tokens. Figure 9.3 shows that there is a large spread of investments. Most frequently individuals invest 10 tokens. It never occurred, with any group or in any round, that all 8 participants invested 8 tokens, as the theoretical equilibrium calculations for rational egoists predicted. Thus although individuals experience the same action situations, the results differ among the action arenas because people make different decisions.

9.3 Changing the CPR action situation

Now that we have the baseline results of the experiments in a CPR context we can explore how the results will change if we make some small modifications to the action situation. These changes are operationalized in the set of instructions given to participants and in the procedures adopted within the experiment.

9.3.1 Communication

The first change that we will look at relates to the information component of the action situation. Instead of forbidding communication among participants as in the baseline experiments, participants are now allowed to communicate with one another on a face-to-face basis in a group setting before returning to their own enclosed terminals to make their private decisions. The participants can talk about whatever they want as long as they do not promise side payments or threaten each other. This kind of communication is known as "cheap talk." "Cheap talk" describes agreements and promises that can not be enforced. If participants behave according to the traditional model of rational egoists, the option of cheap talk should have no effect. Promises cannot be enforced and the decisions are

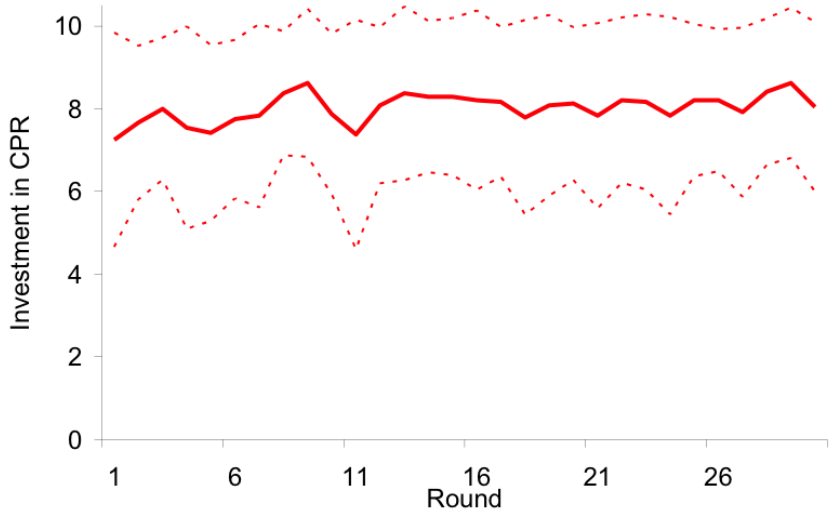

Figure 9.2: Average investment level per person in the common-pool resource. The dotted line represents the average +/- the standard deviation.

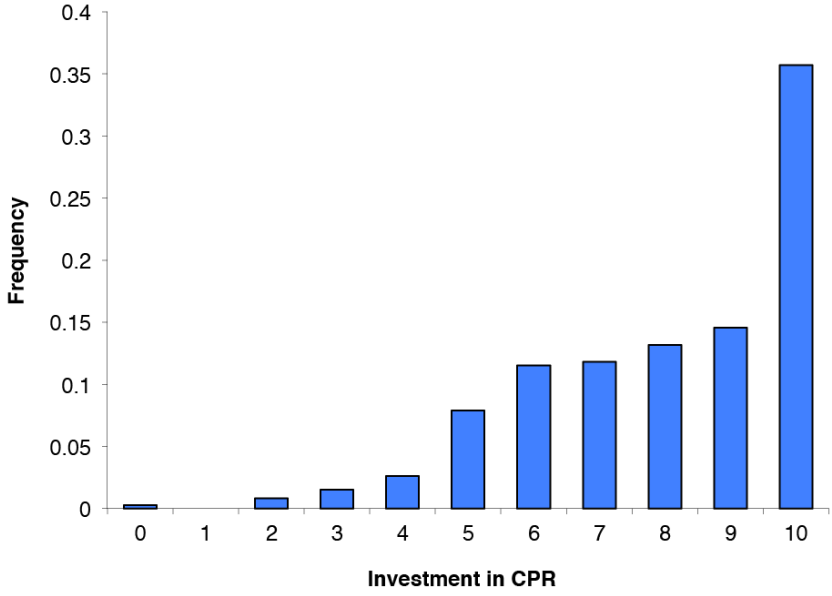

Figure 9.3: Distribution of the investment levels into the CPR.

private. If participants' decisions were known to each other, there might be reputation effects, like people getting bad feedback on eBay.

In the basic communication experiments held at Indiana University in the late 1980s, participants first made ten rounds of decisions in the context of the baseline appropriation situation with no communication. After the tenth round, participants listened to an announcement that told them they would have an open group discussion before each of the next rounds of the experiment. The participants left their terminals and sat in a circle facing one another. After each discussion period, they returned to their terminals to enter their anonymous decisions. Participants used face-to-face communication to discuss which strategy would gain them the best outcomes and to agree on what everyone should invest in the subsequent rounds. After each decision round, they learned what their aggregate investments had been, but not the decisions of individual players. Thus they learned whether total investments were greater than the total investments they had earlier agreed upon. While in many rounds participants did exactly as they had promised one another they would do, some defections did occur. If promises were not kept, participants used this information about the aggregate investment levels to castigate the unknown participant who had not kept to the agreement.

This opportunity for repeated face-to-face communication was extremely successful in increasing joint returns. In the 10-token experiments, participants obtained close to 100 percent of the maximum available returns. Only in 5% of the cases did a participant invest more in the common-pool resource than was agreed upon. The results show that a random group of undergraduate students quickly reached the group maximum, while the prediction using the rational egoist model was that they would still overharvest the resource. Although there was no formal punishment possible, participants used strong language if they detected somebody had invested more than what was agreed upon.

The participants had probably internalized norms regarding the importance of keeping promises. They were also not shy to express anger if participants broke their promises and those who did promised to do better next round.

9.3.2 Costly sanctioning

Participants in field settings are frequently able to communicate with one another on a face-to-face basis, at least from time to time, either in formally constituted meetings or at social gatherings. In many field settings, where the resource has been sustained over a long time, participants have also devised a variety of formal or informal ways of monitoring and sanctioning one another if rules are broken. Engaging in costly monitoring and sanctioning behavior is, however, not consistent with the theory of a norm-free, perfect rationality. Costly sanctioning means that individuals have the opportunity to pay to reduce earnings of another participant in the experiment. Thus, new experiments were held to test whether participants would actually pay from their own earnings in order to sanction the less cooperative behavior of other participants.

As in the communication experiment, participants first participated in ten rounds of the baseline game. Participants were then told that in the subsequent rounds they would have an opportunity to pay a fee in order to impose a fine on the payoffs received by another player. The fees ranged across many different experiments from \$0.05 to \$0.20 and the fines from \$0.10 to \$0.80. In brief, the finding from this series of experiments was that much more voluntary costly sanctioning occurred than the zero level predicted by the rational egoist model.

Participants react both to the initial cost of sanctioning and to the fee-to-fine relationships. They sanction more when the cost of sanctioning is less and when the ratio of the fine to the fee is higher. Sanctioning is primarily directed at those who invested more in the common-pool resource. A few

sanctions, however, appear to be a form of "blind revenge." These were fines made by participants who had themselves been fined by unknown others for their high levels of investment. In these few cases, the sanctioners picked on those whose investments were lower than others, and thus were suspected of being the ones who had previously sanctioned them.

In this set of experiments, participants were able to increase their returns since participants reduced their investments, although they did not reach the maximum earnings. However, if we look at the net earnings, after subtracting the costs of the sanctioning system, we don't see any benefit from sanctioning. On the other hand, the performance was greatly increased if the participants had the opportunity to communicate for just one round.

Outside of the lab, participants rarely impose sanctions on one another that have been devised by an external entity, as in the experiments above. In the field, sanctions are much more likely to emerge from an endogenous process of communities crafting their own rules along with the punishments that should be imposed if these rules are broken. Spending time and effort in a linked collective-choice situation designing rules creates a public good for all of those involved. Crafting rules for an operational situation is thus a second-level dilemma.

The traditional theory of the rational egoist predicts that people will not invest time and effort to create rules. That is the reason why many people argue that rules must be designed and imposed by external authorities who then assume official responsibility for monitoring and enforcing these rules and are paid a salary for their work. Since self-organized rules are found in many local common-pool resource situations, it appears that participants frequently do design their own rules contrary to the theoretical prediction. But these processes are difficult to witness in the field.

9.4 CPR experiments in the field

One of the great advantages of laboratory experiments is that they can be replicated very accurately, and modified for new experiments so that one can gain even greater confidence in the findings. One of the critiques of laboratory experiments is the use of undergraduate students, instead of "real" people (i.e., will we get the same findings if we do experiments with people who work on natural resource management every day?).

Juan-Camilo Cardenas has performed a series of field experiments by setting up CPR action situations in school buildings in rural Colombia where participants made decisions in paper and pencil experiments (Figure 9.4). Cardenas invited local villagers who were actual users of local forests for the extraction of firewood, natural fibers, and log timber as well as local water resources.

In order to do these experiments, the instructions were written in Spanish and in a manner that would be easily understood by villagers. Instead of tokens—which are an easy medium for undergraduates to understand—he asked villagers to decide on how many months a year they would spend in the forest gathering wood products as contrasted to using their time otherwise. Each villager had a copy of a pay-off table, which was the same as that of the other seven participants, showing that as the number of months that each individual would spend in the forest increased, she would gain more returns, but that the return to all of them depended on keeping their

Figure 9.4: Juan Camilo Cardenas explaining an experiment in the field in Colombia.

harvesting time to a very low level.

Would the findings from experiments with villagers in rural Colombia be similar to those conducted with undergraduates at universities in the U.S.? In the baseline, no-communication experiments, Cardenas found a similar pattern as in laboratory experiments. Villagers substantially overinvested in the CPR. The average earning for a participant was about one day of paid labor for an exercise of two or three hours. However, they could double their earnings if the participants could agree to cooperate. Face-to-face communication significantly increased the performance of the groups, although not quite to the maximum level.

9.5 More dynamic CPR experiments

So far, the experiments all have the following sequence: (1) Participants each make private decisions on how much to appropriate from the CPR by investing tokens (time) in appropriation activites. (2) When everybody has made their decision, the aggregated information about the consequences of the decisions of the group are shared with the participants. (3) Then a new round starts where the participants have the same payoff information.

In reality people make decisions all the time. Some make more decisions than others. And some decisions cause immediate consequences (if the irrigator takes too much water upstream, downstream irrigators immediately experience a shortage of water). To better approximate real-world decision making, new experiments were developed using computer simulations where participants make decisions in real-time in a spatially explicit dynamic environment (Janssen, Holahan, Lee, & Ostrom, 2010). This experiment includes more realistic ecological dynamics. Will the results of earlier experimental designs still hold?

Let's consider this more complex environment in a bit more detail. The participants collect tokens from a shared renewable resource environment. Groups consist of five participants who share a 29 x 29 grid of cells (borders not wrapped around) (Figure 9.5). At the start of the experiment, 25% of the grid space is filled with tokens, thus 210 tokens are randomly allocated on the board. Each participant is assigned an avatar, which they are able to control using the arrow keys on the computer keyboard to move up, left, right and down. The avatars are initially placed in the middle row of the screen with equal distances between the avatars. When the participant wishes to harvest a token, they must position their avatar on top of a token and press the spacebar. Each token harvested is worth a certain amount of money defined by the experimenter. Participants have complete information on the spatial position of tokens and can watch the harvesting actions of other group members in real time (the entire screen is visible to the participants). Furthermore, they can see the total number of harvested tokens of all the participants at the top of the screen.

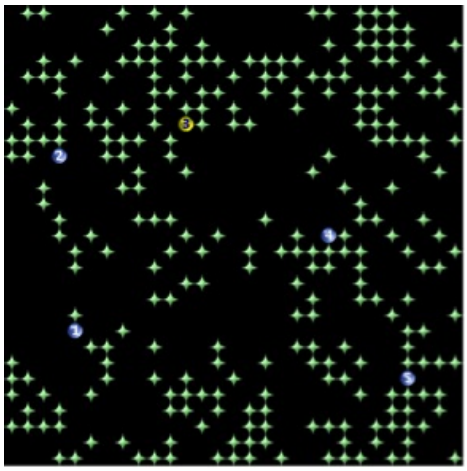

Figure 9.5: Spatially explicit resource.

Every second, empty cells have a possibility of generating a new token (in the same way that land can generate new resources over time). The probability, p_t, that a given empty cell will generate a new token is dependent on the number of adjacent cells containing tokens. The probability p_t is linearly related to the number of neighbors: $p_t = P * n_t/n$ where n_t is the number of neighboring

cells containing a token, n is the total number of neighboring cells ($n = 8$), and $P = 0.01$). If an empty cell is completely surrounded by eight tokens, it will generate a token at a higher rate than an empty cell that abuts only three tokens (can you think of the ecological equivalent of this process?). The model space is not toroidal, so cells located at the edges of the screen have fewer neighbors than interior cells. For example, a corner cell only has 3 neighbors ($N = 3$). At least one adjacent cell must contain a token for a new token generation to occur. Therefore, if participants appropriate all of the tokens on the screen, they have exhausted the resource and no new tokens will be generated (i.e., they have caught every last fish, so there are no more fish to reproduce, and the fish population becomes extinct). By designing the environment in this manner, the experiment captures a key characteristic of many spatially-dependent renewable resources.

The results of the experiments show that we see a tragedy of the commons in experiments without communication or costly sanctioning. Within two minutes the individuals have collected the last available token on the screen and spend the remaining 2 minutes of time in the round staring at a black screen (Figure 9.6). If we repeat this situation, we get the same results. This means that there is no learning that might avoid the tragedy of the commons. If we allow participants to chat for a few minutes, the performance is significantly increased. We can see this in Figure 9.6 since the resource stays at a higher level, leading to more regrowth of the resource. The earnings increase from 53 to 94 tokens per round per person. Note that here the participants do not communicate face-to-face but only exchange messages via a text screen. Nevertheless the group can achieve a result that is substantially better than without communication. Interestingly however, if we allow costly punishment, we do not see an improvement if it is not combined with communication. Because participants are afraid of retaliation in this interactive environment, costly punishment alone is not effective. These experiments show that communication is much more important than the ability to sanction each other.

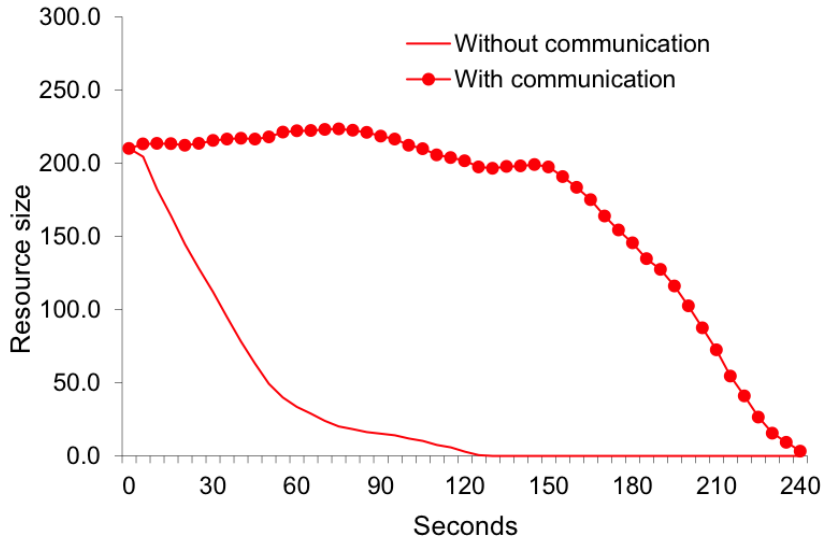

Figure 9.6: The resource size (number of tokens) over time for rounds with and without communication.

9.6 Public good action situations

Public goods are goods that people can consume without reducing the available amount left over for others. Examples are national defense, broadcast television, information on the Internet, levies, etc. However, the provision of the public good requires investments by individuals. The dilemma is to get individuals to invest effort in creating a public good that everybody, even those who may not have contributed, will enjoy.

Public goods are widely studied in experimental settings. We can describe the action situation in the following way:

1. *Participants.* A set of n persons.
2. *Positions*. No differentiation exists in the positions these participants hold relevant to the public good. In other words, there is only one position of contributor.
3. *Actions*. Contributors must decide how to allocate tokens assigned to them in each time period. Basically, one can think of these contributors as being "endowed" with a number of tokens, e, which they are free to allocate in any proportion during each time period to two activities. In a field setting one can think that every day, each appropriator must decide between spending time trying to write articles for Wikipedia or using their time to earn money in an office job. To simplify the problem, we posit that all contributors have the same endowment (just as we all have only twenty-four hours per day), and face the same outside opportunity. Thus, they have to decide how much of their endowment to devote each round to investing into the public good or in gaining returns from an outside option.
4. *Outcomes*. The actions participants take affect the size of the public good generated and shared among all the participants.
5. *Action-outcome linkages*. The function maps the actions of all the contributors into outcomes. Initially, the sum of all of the individuals' contributions, Σx, generates a public good. The more the contributors decide to allocate to the public good, the larger the public good will be.
6. *Information*. As an initial information condition (because of the instructions carefully given to all participants), we assume that contributors know payoff function. Information about outcomes is generated after each decision round is completed. Contributors may not communicate with one another. It is assumed that each contributor will assume that all other contributors are rational actors and will adopt the "best response" as their own actions. These best response functions should lead all contributors not to contribute.
7. *Potential payoffs*. Payoff functions specify the value of the wage rate (ω) and the marginal per capita return (r). An experimental linear public-good game involves a free-rider problem if $r < 1$ and $n \cdot r > 1$. Suppose, in a given round, individual i contributes x_i of ω for the provision of the public good. The participant's payoff is:

$$\omega - x_i + r \sum_{j=1}^{n} x_j \tag{9.2}$$

You can see that the structure of this public good action situation is similar to the CPR action situation. The key difference is the potential payoff from different allocations. The equilibrium prediction, assuming individuals maximize their own monetary payoffs, is that the public good will not be provided at all. The persistent finding from experiments is that initially people invest roughly

half their endowment in the public good. In further rounds, the level decreases over time to a level that depends on the marginal per capita return.

Figure 9.7 shows the basic results with a group size $n = 4$, $r = 0.4$ and $\omega = 20$. Thus when all participants invested their complete endowment to the public good, each participant earned 32 units, which is 60% higher compared to the situation in which none of them invest anything at all.

These results are published in Fehr and Gächter (2002). In this series of experiments, they tested the effect of costly sanctioning (called punishment in the original article). With costly sanctioning the following decision was added after the investment decisions were made. Each participant got the information about the investment decisions of every other group member, and the participants could then decide how much to invest in sanctioning. Up to 10 units could be invested in costly sanctioning. For each token invested in sanctioning, the other participant's earning was reduced by 3 units.

A clever aspect of this particular study was that many groups played during the same time. Each round, the computer rearranged the groups during a series of 6 rounds. As a consequence, a participant was never in a group with the same person for more than one round during a treatment. This was done to avoid reputation effects. Variations in the level of cooperation could have been caused by the reputations of participants in the group.

In rounds without costly sanctioning, we see a rapid reduction of the investment level, while inclusion of costly sanctioning leads to an increase of cooperation. The effect is the same independent of the order of when costly sanctioning is included. This suggests that inclusion of costly sanctioning increases cooperation, but that this effect is removed the moment costly sanctioning is not possible anymore.

9.7 Communication and costly sanctioning

Why does communication and costly sanctioning increase cooperation? Why does costly sanctioning increase cooperation but not the net earnings? These questions are part of several current research efforts. You may find it surprising to learn that there are various possible explanations and, therefore, there is no common agreement on the best possible explanation.

Costly sanctioning happens spontaneously in many of these experiments. People invest in sanctioning others and this leads to a higher level of cooperation. But there is, well, a cost to costly sanctioning! The net earnings are not higher than those compared to treatments without any possibility to sanction. So why do people sanction in the first place? Interestingly, sanctioning experiments in which people only get warnings with no monetary penalty also show an increase in cooperation. Furthermore, if experiments last many rounds, we see net gains when using sanctions is allowed. There is also an ongoing debate on the effectiveness of using penalties for not cooperating compared to *rewards* to increase cooperation (the old adage of the carrot versus the stick). Including the option to give other participants a reward for cooperative behavior, for example, also increases cooperation.

What makes communication so effective? One explanation is that people start feeling like they belong to a group. Instead of competing against each other as is seen in the no communication rounds, communication seems to lead to a group effort. Others argue that communication leads to further explanation of the experiment through group discussion (i.e., learning) so that everybody understands what is best to do. Another explanation is that communication enables people to guess how much they can trust others and confirm social norms. Experiments have been performed where participants watch a video recording of a discussion on the best strategy, or a recording of a professor explaining the possible strategies. In the end, mutual communication within the group was found to

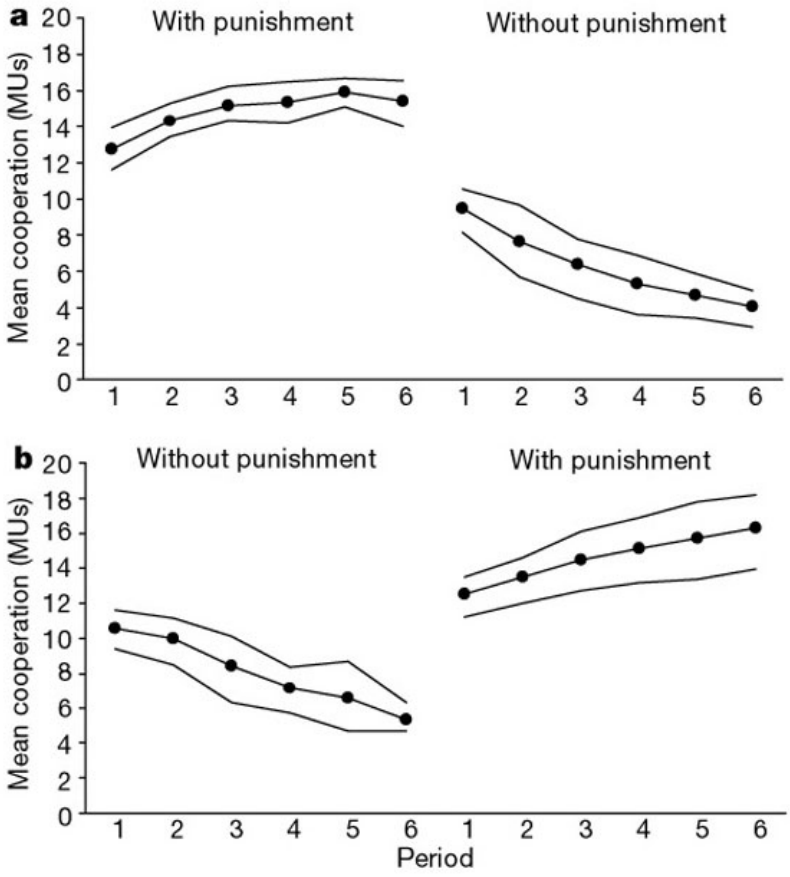

Figure 9.7: a) During the first six periods, subjects have the opportunity to punish the other group members. Afterwards, the punishment opportunity is removed. b) During the first six periods, punishment of other group members is ruled out. Afterwards, punishment is possible (Source: Fehr and Gächter, 2002).

be most effective.

Given the experimental work on governance in laboratory settings, at a minimum we can say that the specific ways costly sanctioning and communication were implemented in the experiments will have a significant impact on the results. Nevertheless, the basic notion that communication and costly sanctioning have positive effects on governance is an important topic in subsequent chapters in which we will analyze practical case studies on public goods and common-pool resources.

9.8 Critical reflections

When experiments are performed with common-pool resources or public goods in the lab or in the field, the results with actual humans typically contrast significantly with the theoretical predictions of what rational egoists would do. There is some cooperation, although we also see under-provision and overharvesting in the experiments. Inclusion of communication and costly sanctioning increases the level of cooperation.

9.9 Make yourself think

1. Come up with an example in which you used sanctioning?
2. Provide examples when communication alone might be sufficient to achieve cooperation (in contrast with writing a contract).

9.10 References

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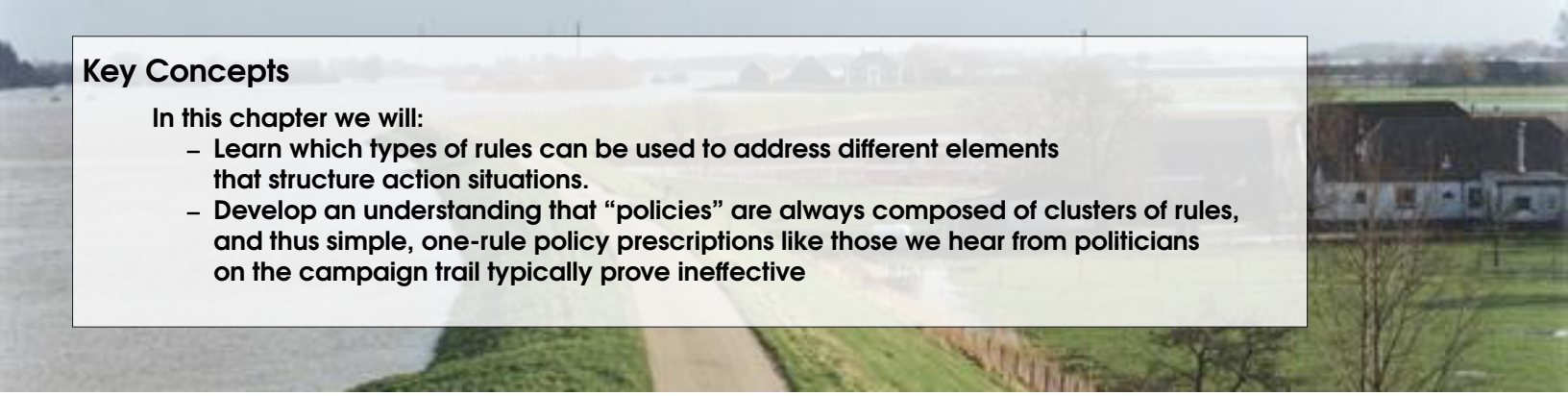
Part IV

Rules of the Games



Key Concepts

In this chapter we will:

- **Learn which types of rules can be used to address different elements that structure action situations.**
- **Develop an understanding that "policies" are always composed of clusters of rules, and thus simple, one-rule policy prescriptions like those we hear from politicians on the campaign trail typically prove ineffective**

10 — Classifying Rules

Organizing a Surprise Party

A surprise party can be considered an action situation where different participants have different positions, information and choices. When you organize a surprise party there are different rules and norms to take into account. These rules and norms are informal; they are not written down on paper. Nonetheless, it is advisable to follow these rules for a successful event. Once a date has been set for which the guest of honor is available, an assistant is appointed to create a fake activity. Guests are invited and are explicitly told that it is a surprise party. All guests need to arrive about half an hour before the arrival of the guest of honor and they need to park their cars out of sight.

The informal rules define the positions of the participants (guest of honor, organizer, assistant, and guests), the boundary rules when people can participate in the event (needs to be invited), define the information one has (do not share information with guest of honor!), define the choices (guest of honor has limited choices). If these rules are followed the payoff is a successful surprise party.

This example shows that there are different types of rules that define specific aspects of the action situation. In this chapter we will discuss what kinds of rules relate to the different variables of the action situation.

10.1 Introduction

In this chapter we will discuss consistent ways to group rules. In empirical research many different types of rules are found. Elinor Ostrom developed a way to classify the rules in order to study and understand institutions.

The motivation for classifying rules relates to addressing questions such as "which rules need to be changed to solve a particular problem?" or "which are the most cost effective rules to change to achieve a certain outcome?" Such questions may arise in response to a vast array of problems from global challenges such as how to change the incentives facing users of fossil fuel to reduce CO_2 emissions so as to reduce the impact of climate change, to local issues such as how to change the parking regulations on a university campus to increase accessibility.

Policy analysts may want to fix a dysfunctional action situation as a doctor wants to heal a sick patient, a mechanic wants to repair a car, or a computer technician wants to solve a telecommunications problem. The policy maker needs to understand the workings of the action situation if she wants to attempt to solve problems of poor performance. What is the actual problem leading participants in an action situation not to cooperate to sustain the commons? Because action situations can be extremely complex, policy makers (an to an even greater extent, politicians) can fall back on ideology, which may lead to policy panaceas such as "cut taxes and everything else will take care of

itself." Ideology might not be the best guidance to dissect the problems that societies face. Based on a physician's sophisticated understanding of the workings of the human body, she will perform a number of diagnostic checks to identify the fundamental causes of the illness.

The policy analyst needs to understand the action situation and the consequences of different interventions on the outcomes. This understanding is ideally based on experience and a good theoretical framework. Instead of assuming all situations are the same and we just have to apply a blue print solution, the policy maker needs to understand the local context to identify the appropriate response. The classifications of rules as discussed in this chapter may help the policy analyst to perform a proper diagnosis.

10.2 How to classify rules

In Chapter 4 we identified the components of action situations that are used to construct a wide variety of analytical models of markets, hierarchies, firms, neighborhood associations, common-property governance regimes, etc. The elements are participants, positions, actions, outcomes, information, control, and costs/benefits. They are related in the following manner:

- *Participants* and *actions* are assigned to *positions*
- *Outcomes* are linked to *actions*
- *Information* is available about *action-outcome linkages*
- *Control* is exercised over *action-outcome linkages*
- *Costs and benefits* are assigned to *action-outcome linkages*

Participants, who can either be individuals or any example of a wide variety of organized entities, are assigned to positions. In these positions, they choose among actions allowed for these positions in light of the information available to them, the control they have over action-outcome linkages, and the benefits and costs assigned to actions and outcomes.

For example, within a sport league, participants include players, coaches, teams, etc. Each of those participants is permitted to undertake a limited number of actions. A coach decides which players will play in the game, while the player is making operational decisions allowed by the rules in split second intervals during the game. Information available in an action situation is not available for everyone. Tactics of teams are not publicly shared, and a player may not reveal some shin splint problems to his coach because she wants to play that night. Winning and losing games has major consequences for teams. Will they win a key tournament and get promoted to a higher-level league? Although teams and team members will benefit from winning the game, individual players also want to shine to get more lucrative contracts.

The relationships among the various parts of the action situation are represented within the square in Figure 10.1. Potential outcomes from a particular pattern of actions can be evaluated using criteria like efficiency and equity. If an actor wants to influence the outcomes of this action situation, rules may be crafted in order to do so. For example, if the action situation is a one-shot prisoners' dilemma without communication, an increase in cooperation could be achieved by allowing communication between the players. If there is a desire to increase the efficiency of a university, more strict admission standards can be crafted.

We are now in a position to start classifying rules. The classification of a rule is based on the element in the action situation that is most *directly* impacted by that rule. Many rules also indirectly affect other components of the action situation via the interactions among the components involved

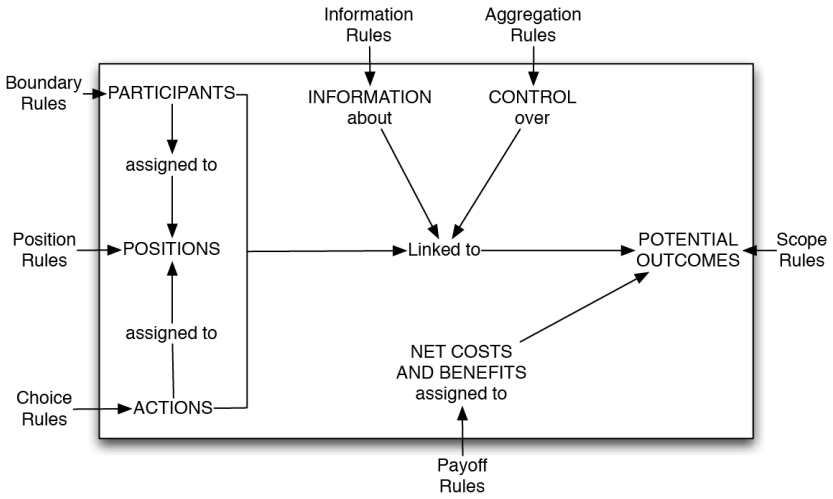


Figure 10.1: Rules as exogenous variables directly affecting the elements of an action situation (adapted from Ostrom 2005).

in the action situation.

We use the action situation to classify seven broad types of rules: position, boundary, choice, aggregation, information, payoff and scope. Position rules create positions (e.g., member of a legislature or a committee, voter, etc.). Boundary rules affect how individuals are assigned to or leave positions and how one situation is linked to other situations. Choice rules affect the assignment of particular action sets to positions. Aggregation rules affect the level of control that individual participants exercise at a linkage within or across situations. Information rules affect the level of information available in a situation about possible actions and the link between actions and outcomes. Payoff rules affect the benefits and costs assigned to outcomes given the actions chosen. Scope rules affect which outcomes must, must not, or may be affected within a given domain.

In Figure 10.1, arrows illustrate how different types of rules relate to specific parts of the action situation. We can also look at the different types of rules from a language perspective. Which verbs are most likely used to express the rule? In Table 10.1 we provide verbs that closely resemble the intent of specific rules. For example, most boundary rules will specify the conditions for when somebody can *enter* or *leave* a position.

Type of Rule	Basic AIM Verb	Regulated component of the action situation
Position	Be	Positions
Boundary	Enter or leave	Participants
Choice	Do	Actions
Aggregation	Jointly affect	Control
Information	Send or receive	Information
Payoff	Pay or receive	Costs/Benefits
Scope	Occur	Outcomes

Table 10.1: The AIM component of each type of rule

Specific rules can have an impact on the whole action situation. Take for example the local medallion ordinance for taxis in urban areas. A boundary rule might be that only taxis who display a purchased medallion from the city can legally use the city streets to attract customers. This has been the case in New York City for decades. When a city limits the number of medallions it will authorize, the entry costs for putting a taxi on the streets rise substantially if demand is rising. But if the medallions are strictly limited, the potential returns per unit of time also increase substantially, and the time the traveler has to wait for a taxi may also increase.

Around 2000, the Dutch government changed the boundary rules for taxis in the Netherlands. Until that time, there were strict boundary rules for cities. The minister of Economic Affairs argued that it would be more efficient to open the market and let taxis freely attract passengers within the whole country. It was expected that competition between taxis would increase performance and reduces prices. However, taxis flocked to Amsterdam, the city with the most potential clients, and the original taxi company acted to defend their territory. The so-called taxi war led to taxi drivers fighting physically for passengers and some taxis were burned in the process. Further, many taxi drivers without much knowledge of Amsterdam city streets ended up driving tourists, who also did not know their way around. After ten years, the government concluded that the policy change (boundary rule change) led to higher prices and reduced the quality of the taxi service. Could the government have used a policy analysis framework like the IAD to foresee this unintended consequence?

10.3 The seven types of rules in detail

10.3.1 Position rules

As discussed in Chapter 3, an important component of an action situation is the set of positions that participants can occupy. Position rules create these positions. Since various rules relate to actions that participants in certain positions may, must or must not make, these position rules have important consequences. The position rule creates the scaffolding for a wide diversity of situations that can vary significantly in terms of the number of positions and the relative authority assigned to each position in a given action situation.

A position rule could be defined such that all people in the action situation occupy the same position. Other position rules define more specific positions, such as the chair person or referee.

A position rule may also state whether there is a limit to the number of participants that can occupy a certain position. Most sports have rules regarding how many players of a team are allowed to be on the field. For example, soccer teams have a maximum of eleven field players and a minimum of eight field players. For a senate to make decisions, a certain quorum needs to be met, meaning that a minimum number of senators needs to be present in order to make binding decisions. Sometimes the maximum number of participants in a certain position is restricted by the biophysical conditions. For example, the maximum number of students who can take a course is often defined by the official number of seats available in a classroom.

10.3.2 Boundary rules

Boundary rules are often called entry and exit rules. They define (1) who is eligible to enter a position, (2) the process that determines which eligible participant may enter (or must enter) positions, and (3) how an individual may leave (or must leave) a position. For example, during a soccer game a coach can bring in a new player if an existing player is taken off the field. Depending on the sport, there are specific rules regarding how many switches a team is allowed to make during a match.

Thus, some entry rules specify the criteria to be used to determine whether an actor is eligible to fill a particular position. Ascribed and acquired attributes are frequently used in this type of entry rule. Individuals may have to meet certain physical standards, such as height and weight. Think about boxing (weight) or the military (weight and height). They may have to meet a certain wealth standard or pay an entry fee (a golf country club). Individuals may be required to possess a certain range of experiences, to be above a minimum age, to have graduated from certain schools, to be the descendants of a particular group, to possess certain abilities, or to live in certain geographical areas. Public employment under civil service systems and patronage systems differs substantially with respect to the entry rules that are applicable.

When those crafting a rule hope to increase the skills and knowledge held by those in a position, they may list one or more acquired characteristics, such as holding a college degree or passing a test. For example, to become a tenure-track professor at most public universities within the U.S. one is required to have acquired a relevant PhD degree. Contentious debates have and will continue to erupt over whether one or another attribute should be included in a rule. For example, in the past, race was used to deny access to many public places for black citizens within the U.S.

Sometimes boundary rules are not specific about the attributes of individuals who may occupy positions. For example, boundary rule for a party might simply be "those invited may attend." Boundary rules do not always include a choice. A suspect that has been arrested by the police has no choice as to whether to participate in court proceedings concerning charges made by the state (i.e., be in the position of defendant). The suspect also has no choice in exiting his/her position. Other examples of compulsory positions taken by participants are those who are drafted into the army, serve on a jury or pay taxes.

10.3.3 Choice rules

Choice rules specify what a participant occupying a position must, must not, or may do at a particular point in a decision process in light of conditions that have, or have not been met at that point in the process. The actions that participants must, must not, or may do are dependent both on the positions they hold, prior actions taken by others and/or themselves and attributes of relevant state variables.

A suspect in a criminal case has limited choices: what to plea, whether to hire a lawyer, whether or not to testify on his or her own behalf. A parent has many choices to make and often needs to make choices for their children, especially if they are under 18 years of age.

The choices available also depend on the conditions of particular actions. If a carpenter injures his hand while hammering a nail on the job, the carpenter may be elegible for compensation because of the arrangements related to activities of the workplace. If the carpenter gets injured at home, outside of the work situation, no such compensation may be received. The carpenter may be a member of a club that provides members with disability insurance, but that choice is related not to the position of "employee" but, rather, to the position of "member of group insurance plan."

In many bureaucratic action situations, no one participant is authorized to take particular positive actions unless specific conditions are met. A power-plant employee, for example, may not be authorized to open a turbine unless water levels are above a minimum. A social worker cannot authorize food stamps or welfare payments unless an applicant's income is below some defined level given the size of the family and other conditions.

Choice rules affect the basic rights, duties, and liberties of individuals involved in an action situation. Choice rules may be allocated to positions with high levels of control, such as the President of the United States.

10.3.4 Aggregation rules

Aggregation rules determine whether a decision, made by a single participant or multiple participants, is needed prior to an action at a node in a decision process. In chess each participant is authorized to make a move when it is his or her turn. The player's action set at that juncture includes the specific physical moves to be made. While no single player fully controls the final outcome, individual players do control the decisions to be made at individual decision moments.

However, in many legislative action situations, multiple participants jointly control which actions will be taken. Members of the legislature may amend or not amend a bill, and can cast votes that are then aggregated by an aggregation rule. No single participant has full control over the move to amend or not to amend the bill.

Aggregation rules are necessary whenever choice rules assign multiple positions partial control. Aggregation rules need to clarify for a group "who is to decide." "A new president is elected if one candidate gains 50% of the votes plus one vote," is an example of an aggregation rule. This is the majority rule. Another example is the unanimity rule, where all participants in an action situation need to agree with a proposed action in order to continue with that action (e.g., in a trial by jury, the jurors must agree unanimously on the verdict). Another example is that one actor can block actions using a veto. For example, some members of the United Nations Security Council can veto proposed resolutions.

Sometimes different participants have complementary attributes. A bank clerk, for example, is not authorized to open safety deposit boxes unless the owner of the box or an authorized agent signs a registration form and produces a second key to fit the box.

10.3.5 Information rules

An important part of any action situation is the information available to participants about the overall structure of that situation, the current state of the attributes of the participants, the previous and current decisions of other participants in related positions, and their own past decisions. Information rules affect the level of information available to participants. Information rules authorize channels of information flow among participants, assign the obligation, permission, or prohibition to communicate to participants in positions in particular situations, and the language and form in which communication must take place. Information rules are particularly important in generating information about past actions of participants so that other participants can know who is, or is not, trustworthy.

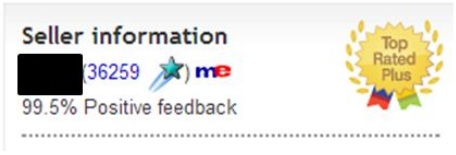
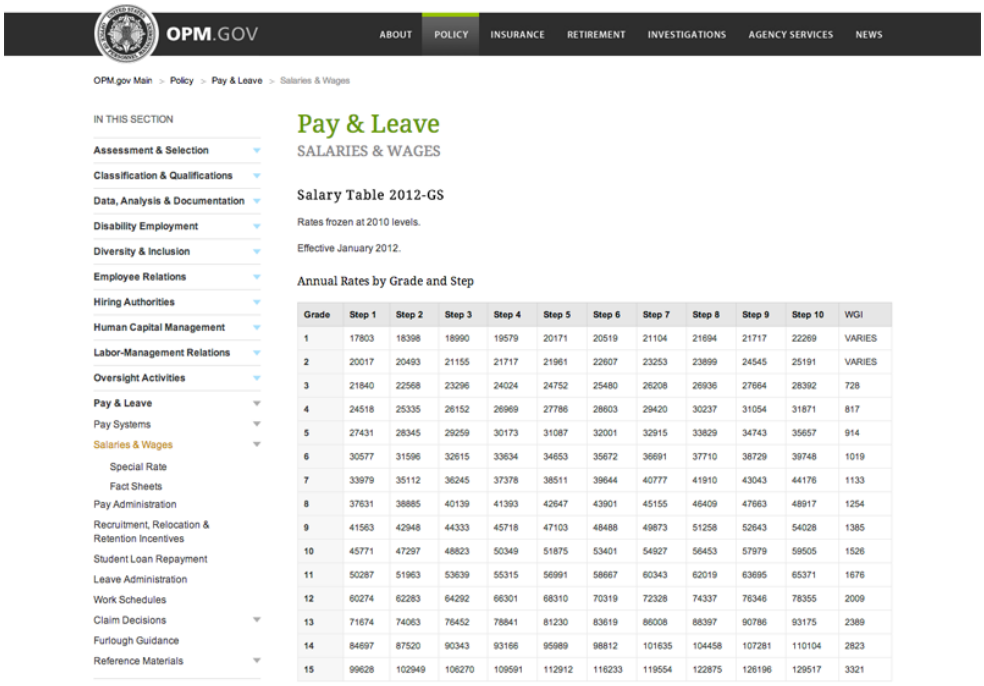


Figure 10.2: Sellers must earn the designation of top-rated seller based on customer feedback.

On eBay, for example, you can see feedback about past transactions of the buyers and sellers that enable you to make decisions whether to pursue the transaction or not (Figure 10.2). Each state and country has rules on which languages can be used to write official documents. To board a plane, your boarding pass must have your legal name exactly as it appears in your passport or drivers license.

How open is the U.S. federal government about how decisions are made? When are minutes of meetings made available? Can the general public observe a court case or meeting? What sort of actions must someone who is on probation report to a probation officer on a regular basis?



Grade	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	WGI
1	17803	18398	18990	19579	20171	20519	21104	21694	21717	22269	VARIES
2	20017	20493	21155	21717	21961	22607	23253	23899	24545	25191	VARIES
3	21840	22568	23296	24024	24752	25480	26208	26936	27664	28392	728
4	24518	25335	26152	26969	27786	28603	29420	30237	31054	31871	817
5	27431	28345	29259	30173	31087	32001	32915	33829	34743	35657	914
6	30577	31596	32615	33634	34653	35672	36691	37710	38729	39748	1019
7	33979	35112	36245	37378	38511	39644	40777	41910	43043	44176	1133
8	37631	38885	40139	41393	42647	43901	45155	46409	47663	48917	1254
9	41563	42948	44333	45718	47103	48488	49873	51258	52643	54028	1385
10	45771	47297	48823	50349	51875	53401	54927	56453	57979	59505	1526
11	50287	51963	53639	55315	56991	58667	60343	62019	63695	65371	1676
12	60274	62283	64292	66301	68310	70319	72328	74337	76346	78355	2009
13	71674	74063	76452	78841	81230	83619	86008	88397	90786	93175	2389
14	84697	87520	90343	93166	95989	98812	101635	104458	107281	110104	2823
15	99628	102949	106270	109591	112912	116233	119554	122875	126196	129517	3321

Figure 10.3: The U.S. government service (GS) pay-scale. There are very specific rules to enter and leave the different positions (GS-1, GS-2), etc. Within each GS position there are 10 different salaries (e.g, a GS-8, step 5 salary is $42,647).

10.3.6 Payoff rules

Payoff rules assign external rewards or sanctions (fines) to particular actions that have been taken by participants or to the assessment of particular outcomes. An example of a set of payoff rules is the pay schedule that is used by a government agency or by a private firm to assign salaries to participants in particular positions (Figure 10.3). Payoff schedules may vary in terms of the variables taken into account and the complexity of the schedule. Hourly wage payoff rules are very simple. Someone being paid according to piecework will, on the other hand, be paid by formula. Performance contracts for corporate exectutives are frequently much more complex and state very explicity when executives qualify for certain kind of bonuses and how they will be paid (in terms of stocks, options, cash, etc.).

10.3.7 Scope rules

Scope rules affect a known outcome variable that must, must not, or may be affected as a result of actions taken within the situation. For example, for a professor to get tenure, they are evaluated on different outcome measures (quantity and quality of publications and quality of teaching). The performance of schools can be evaluated based on many different outcomes as witnessed by the various criteria used for college rankings. Most sports are straight forward in the outcome evaluation, one wins a competition or not. Some sports are based on evaluations by a jury, such as gymnastics, who follow a detailed set of rules to define the score (Figure 10.4). An example of the application of such a scope rule would be as follows: in order for a female competitor to win a sanctioned gymnastics competition (a particular outcome of an action situation), the competitor must achieve the highest combined score on all events (the floor exercise, vault, uneven bars, and balance beam).

Equating achieving the highest combined score on all events with "win" is a scope rule that defines how actions lead to outcomes. Another set of detailed scope rules defines how judges assign points to the actions of participants. Note that both gymnists and judges hold positions in the action situation. What are the boundary rules for them to occupy those positions?

Another example of a scope rule used to manage fishing by Native Americans on the Northwest Pacific coast is that tribe members cannot begin fishing for salmon until the chief has caught and dried the first salmon caught that season.

10.4 Default conditions

Not all possible actions and outcomes of each action situation have rules associated with them. If there were, following the rules would become such a complex task that we would waste all of our time on monitoring and sanctioning the rules and would get nothing done. This raises the quesiton of what are the default situations when there are no explicit rules and what is allowed in those circumstances? To answer this question, we can start defining the default conditions from what is physically possible. Table 10.2 below defines the default conditions for each of the rule types if there are no explicit rules. If the participants adopt internal norms that promote cooperative behavior, such a default position may lead to a positive outcome. However, if some participants cheat, manipulate, or do not cooperate, it becomes clear that explicit rules would be needed to reach a positive outcome in the action situation.

Figure 10.4: Is this a "good" stag leap? Scope rules determine criteria so judges can answer this question consistently.

How do people create rules when they experience a default situation that produces undesirable outcomes? A possible action is to create the position of a leader or a group of leaders who coordinate communication and mediate differences in interests among the participants.

Default positions	
Default Position Conditions	One position exists.
Default Boundary Condition	Anyone can hold this position.
Default Choice Condition	Each player can take any physically possible action.
Default Aggregation Condition	Players act independently. Physical relationships present in the situation determine the aggregation of individual moves into outcomes.
Default Information Condition	Each player can communicate any information via any channel available to the player.
Default Payoff Condition	Any player can retain payoffs from any outcome that the player can physically obtain and defend.
Default Scope Condition	Each player can affect any state of the world that is physically possible.

Table 10.2: Default positions of each type of rule.

10.5 Critical reflections

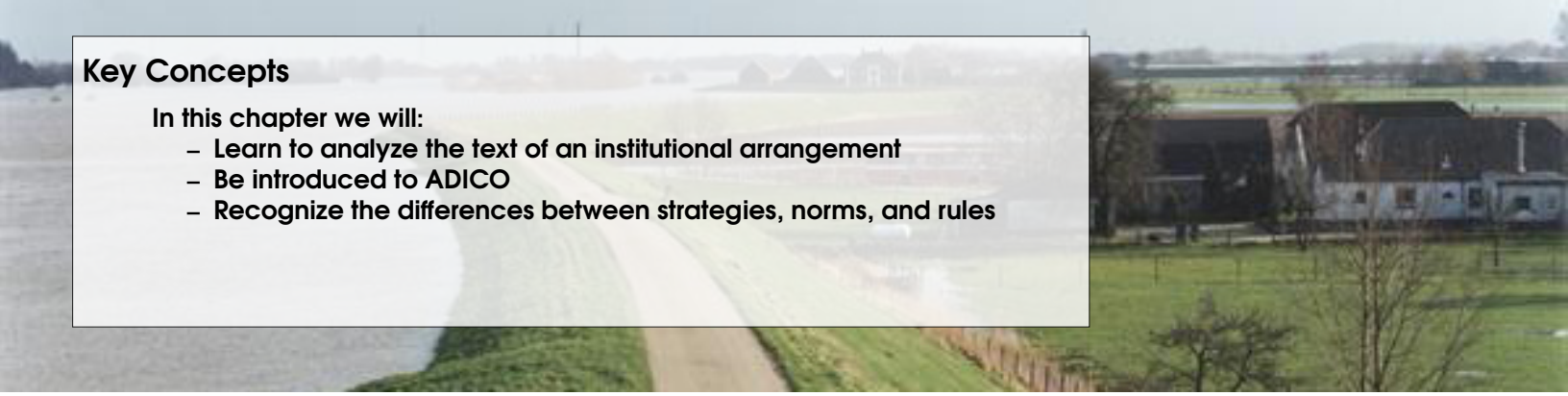
Within action situations we can distinguish different types of rules that define who is part of the action situation, the position she can take, the information that is available to her, and what the payoffs are for different decisions. Defining the different types of rules that provide the "software" for action situations is important if we wish to analyze them in more detail.

10.6 Make yourself think

1. What kind of rules do you have within your household or student dorm? Are there position rules? Choice rules? Boundary rules? Scope rules?
2. What is an example of information rule that holds for students at Arizona State University?

10.7 References

Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.



Key Concepts

In this chapter we will:

- **Learn to analyze the text of an institutional arrangement**
- **Be introduced to ADICO**
- **Recognize the differences between strategies, norms, and rules**

11 — Rules, Norms and Shared Strategies

Consequences

What are the consequences if you don't follow the rules? For example, driving far above the speed limit might have consequences if you are caught. What about your civic duty to vote in elections? What will happen if you don't vote? In the U.S. you don't have to vote, and there are not formal consequences if you don't vote. In Belgium, Austrailia, and many other countries, you MUST vote and there are penalties for not voting without a valid reason.

Not all statements that say what you MUST do and MUST NOT do are rules. In the statement in Figure 11.1, there are no consequences specified if you do take pictures. Of course it would be very impolite not to follow the request, but is the exhibit organizer allowed to throw you out of the exhibit and confiscate your camera?

In the immigration warning in Figure 11.2 Malaysia states clearly that people who are dressed in shabby clothes will be ordered to leave the country. Hence you MUST dress properly OR ELSE you will be ordered to leave the country.

11.1 Introduction

Throughout this book we have used the term "rules," but we have not been very precise in what we mean by it. In fact, scholars have different interpretations of what makes something a rule rather than a shared strategy or a norm. In this chapter we will discuss in more detail how we define shared strategies, norms and rules. Moreover, we will learn some tools for looking at shared strategies, norms and rules in a more systematic way. This will help you to analyze action situations and unravel what the rules and norms are. In fact, a better understanding of the structure of rules will help you with decisions you make in your life.

We will look at written statements about what is allowed or not. If you look carefully around you, you will find many signs and statements that define what is or is not allowed: "only people with a valid permit can park here," "you must show your ID to buy alcohol in this store," "please recycle," etc. In this chapter, we will learn how to analyze these statements in more detail to define what they mean in the context of institutional statements.

An *institutional statement* describes opportunities and constraints that create expectations about other actors' behavior: what may, must and must not be done. In other words, an "institutional statement" encompasses a broad set of *shared* linguistic constraints and opportunities that prescribe, permit, or advise actions or outcomes for participants in an action situation. The importance of these statements cannot be underestimated for the smooth functioning of human societies. Just imagine if

Figure 11.1: Statement when entering exhibition.

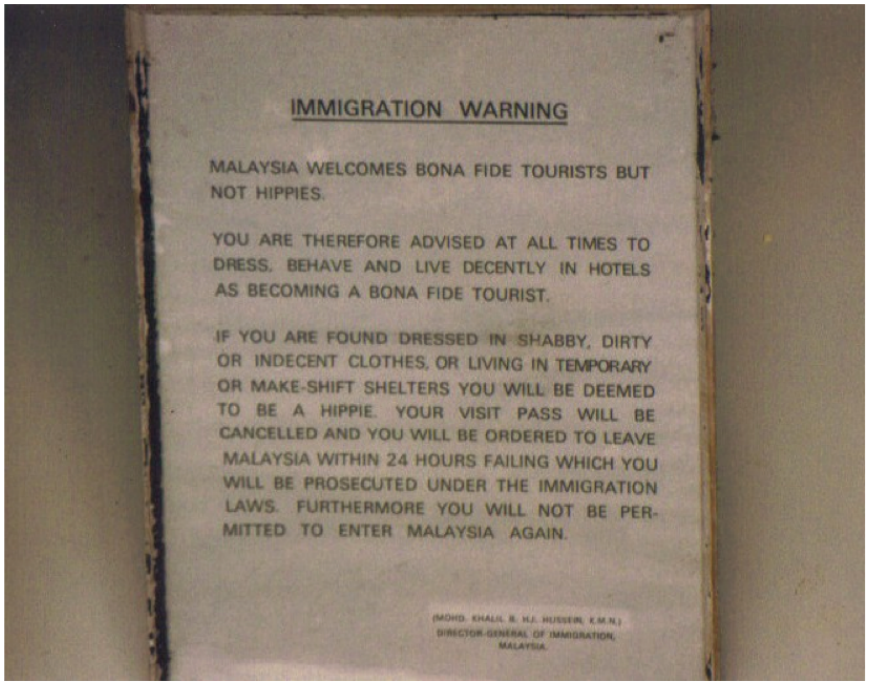


Figure 11.2: Warning on entering Malaysia.

you could not predict at all what others are likely to do in the action arenas in which you participate each day. Not only would you not get much done, you might end up seriously injured or even dead.

The institutional grammar tool, developed by Sue Crawford and Elinor Ostrom, allows analysts to distinguish more systematically between institutional statements that are best understood as shared strategies, norms or rules. Rules can be written down on paper, such as formal laws, but might not be common knowledge to everyone. Do you know all the laws that apply in the jurisdiction that you now inhabit? Rules do not have to be written down on paper. In fact, many rules are actually unwritten, so-called rules-in-use. These are the rules that people actually use in an action situation.

Here are some examples of institutional statements:

1. In order for a person to obtain a hunting license in the state of Arizona (s)he must be 10 years of age or older, a resident of the state of Arizona and pay a fee or else no license will be issued.
2. A customer must produce a valid I.D. if asked by an establishment that sells alcoholic beverages in order to be served alcohol. An underage person who tries to buy liquor with a fake I.D. may be charged with a Class 3 misdemeanor.
3. All lobster fishers in Maine must not put their traps in the fishing territory of neighboring harbor, or else their traps may be cut loose.
4. If you use the microwave, you must clean up your own mess!
5. The person who places a phone call is the one who calls back when the call gets disconnected.

If we look carefully at these institutional statements we can detect regularities. The statements are about certain types of persons who are or are not allowed to do certain activities. And if they do something that is not allowed there might be consequences.

Let us now turn to the syntax that we will use to analyze these and other examples. With a syntax we mean that we can detect common components or building blocks in these statements, and these components have a particular function.

The general syntax of this grammar includes five components and is known as ADICO: ATTRIBUTE, DEONTIC, AIM, CONDITIONS, and OR ELSE. You might compare this to the SUBJECT, VERB, OBJECT, or "SVO" structure of English.

ATTRIBUTES (A) is a place holder for any value of a participant-level variable that distinguishes to whom the institutional statement applies. Examples include eighteen-year-old, female, college educated persons, or persons with one year of experience; or a specific position, such as employee or chairperson. Note, attributes are typically defined by a combination of position and boundary rules.

DEONTIC (D) is a place holder for "may" (permitted), "must" (obliged), and "must not" (forbidden).

AIM (I) is a place holder that describes particular actions or outcomes in the action situation to which the deontic is assigned. An AIM may include a formula specifying an amount or intensity of actions or ranges of outcomes or a description of a process for an action. An example would be harvesting 10 kilograms per day. The aim is typically specified by a combination of choice, scope, information and payment rules.

CONDITIONS (C) is a place holder for those variables that define when and where an action or outcome is permitted, obligatory, or forbidden. Examples include between 6 am and 9 am, in area B, after the first fish is dried, etc. The conditions are typically specified by a combination of scope, choice and information rules.

OR ELSE (O) is a place holder for the assigned consequence for not following a rule.

We will now define the three types of institutional statements using the syntax above. In the same way that a sentence does not need to contain all the possible parts of speech, institutional statements need not contain all the building blocks we have described. The possible institutional statements are:

- Shared strategies contain components AIC; the attributes, aim and conditions. Strategies can thus be written as [ATTRIBUTES] [AIM] [CONDITIONS].
- Norms contain the elements ADIC. Compared to shared strategies, norms include whether an activity is permitted, obliged or forbidden. But norms do not explicitly include the consequences for doing something that is forbidden or not doing something that is required. Norms can thus be written as [ATTRIBUTES] [DEONTIC] [AIM] [CONDITIONS];
- Rules do contain all five elements (ADICO). Regardless of how institutional statements are expressed in natural language, they can be rewritten or summarized in the ADICO format: [ATTRIBUTES] [DEONTIC] [AIM] [CONDITIONS] [OR ELSE].

By writing the statements in a consistent manner, we can then better compare the institutional statements in use in a variety of settings. Note that because language is inherently flexible, the way we characterize the statements below is not the only way to do it.

Let's now apply the ADICO syntax to the five examples above.

In order for a person to obtain a hunting license in the state of Arizona (s)he must be 10 years of age or older, a resident of the state of Arizona and pay a fee or else no license will be issued.

ATTRIBUTES:	[a person who wants to obtain a hunting license in the state of Arizona]
DEONTIC:	[must]
AIM:	[be 10 years of age or older, a resident of the state of Arizona and pay a fee]
CONDITIONS:	[in the state of Arizona]
OR ELSE:	[no hunting license will be issued]

A customer must produce a valid I.D. if asked by an establishment that sells alcoholic beverages in order to be served alcohol. An underage person who tries to buy liquor with a fake I.D. may be charged with a Class 3 misdemeanor.

ATTRIBUTES:	[a customer]
DEONTIC:	[must]
AIM:	[produce a valid I.D.]
CONDITIONS:	[if asked by the establishment in order to be served alcohol]
OR ELSE:	[no liquor will be served][may be charged with a Class 3 misdemeanor]

All lobster fishers in Maine must not put their traps in the fishing territory of neighboring harbor, or else their traps may be cut loose.

ATTRIBUTES:	[All lobster fishers in Maine]
DEONTIC:	[must not]
AIM:	[put their traps in the fishing territory of neighboring harbor]
CONDITIONS:	[-]
OR ELSE:	[traps may be cut loose]

If you use the microwave, you must clean up your own mess!

ATTRIBUTES:	[If you use the microwave]
DEONTIC:	[must]
AIM:	[clean up your own mess]
CONDITIONS:	[-]
OR ELSE:	[-]

The person who places a phone call is the one who calls back when the call gets disconnected.

ATTRIBUTES:	[The person who places a phone call]
DEONTIC:	[-]
AIM:	[calls back]
CONDITIONS:	[when the call gets disconnected.]
OR ELSE:	[-]

11.2 The syntax components

We now turn to a discussion of the components of the ADICO syntax. Understanding the components helps analysts to develop common methods of distinguishing between rules, norms, and shared strategies to cumulate knowledge for key questions such as: "what is the difference between a rule and a norm?" and "what is the difference between a shared strategy and a norm?" We will see that there will still remain some ambiguity in the definitions, but it will be more precise as the terms are commonly used. Especially the distinction between a norm and a rule has some gray areas, which we will touch upon when we discuss the OR ELSE component.

11.2.1 ATTRIBUTES

All institutional statements apply to a subset of participants in an action situation. The subset can range from one participant to all participants. A set of ATTRIBUTES define the participants to whom the institutional statement apply. If individuals make up the participants in an action situation, the ATTRIBUTES will be individual-level values. Individual level ATTRIBUTES include values assigned to variables such as age, residence, sex, citizenship, and position. When the participants governed by a set of institutions are corporate actors, rather than individuals, the ATTRIBUTES refer to organizational variables such as size of membership or geographic location. It should be clear that position and boundary rules are core components of attribute statements.

In the first example, no ATTRIBUTES related to age are specified. To be in the *position* of a valid hunting license holder, a person needs to be 10 years old (a boundary rule). But, a person younger than 10 years old can hunt without a hunting license if the person is accompanied by a

properly licensed person who is 18 years of age or older (another boundary rule), and no more than two unlicensed children may accompany a license holder (a scope rule). The key here is that the institutional statement clarifies how individuals may enter positions and the *choices* open to individuals in that position in different contexts.

Some version of the fourth example, the microwave cleanup statement, can often be found taped to the door of a community microwave. The beginning of that statement, "If you use the microwave," could be interpreted as the ATTRIBUTE of "microwave users" (a position rule with no explicit boundary rule as to who can be in the position of microwave user—it is implied in the context). In the last example, the ATTRIBUTE is the caller who placed the call. The other examples list no specific attribute. When no specific attribute is listed, the default value for the ATTRIBUTE component is all members of the group. This means that the ATTRIBUTE component always has something in it, even when a specific attribute is not contained in the statement. Thus, the second example applies to all people who want to buy alcohol, and the third example apples to all fishers in Maine.

The ATTRIBUTE component can specify which positions in an action situation are referred to in an institutional statement, such as "physicians must maintain confidentiality with regard to patient information."

11.2.2 DEONTIC

The DEONTIC component draws on deontic logic to distinguish prescriptive from non-prescriptive statements. The complete set of DEONTIC operators consists of "permitted," "obliged" and "forbidden." These are general qualifiers for choice rules.

Institutional statements use the operative phrases *may*, *must/should*, and *must not/ should not* to assign these operators to actions and outcomes. "Should" and "must" are both commonly used to oblige a person to act. Similarly, "must not" and "should not" both forbid. For the sake of simplicity, we use "must" and "must not" throughout this chapter in nearly all examples. However, the deontic terms can be used equally well for "should" statements. Generally, in everyday language, "must" obliges someone more strongly than "should," and "must not" forbids someone more strongly than "should not."

One may wonder whether the element "may" is that important. What does it mean that certain actions are allowed? In the United States, consumers above the age of twenty-one *may* purchase alcohol in most states. In some states, Sunday liquor laws constrain this permission further and allow consumers above the age of twenty-one to purchase alcohol only Monday through Saturday (a scope rule limiting the choice rule of purchasing alcohol). In effect, these rules establish the settings in which permission exists and thus forbid the action in circumstances that do not meet the stated CONDITIONS. A rule that grants permission to cut trees with a permit from a forestry agency implies that in the absence of a permit tree cutting is forbidden.

If we look at the examples, we see that in examples 1, 2, 3, and 4 participants must or must not do certain activities. The fifth example has no deontic element, which means that example 5 is a strategy. Both norms and rules have deonitic elements.

11.2.3 AIM

The AIM is the specific description of a working part in an action situation to which an institutional statement refers. The description can include information about a process (filling out a form at the U.S. Post Office) or a formula (pay $10 per hour worked). In order for an institutional statement

to influence behavior, the AIM must be physically possible and the contradiction need also to be physically possible. An individual cannot logically be required to undertake a physically impossible action and prescribing an action can only influence behavior if it is physically possible to not do that action. The capability of voting implies the capability of not voting. Voting for candidate A implies the option of not voting for candidate A. The AIM sometimes specifies states of affairs in the world or an outcome instead of an action. Outcomes, like actions, must also be possible and avoidable to be parts of a well-formed institutional statement. Moreover, any particular outcome implies the existence of the contradicting outcome.

In example (1), the AIM is the minimum age of 10 years, being a resident of Arizona, and the fee that needs to be paid in order to receive a valid hunter's license. In the second example, the AIM is the action of producing a valid I.D. The AIM in the third example is to put traps at the right place. The AIM in the fourth example is cleaning the microwave. Finally, the AIM in the fifth example, the strategy, is the action of calling back.

The AIM often supplies the focus for studies and debates such as the same sex marriage debate.

11.2.4 CONDITIONS

CONDITIONS indicate the set of variables that define when and where an institutional statement applies. For example, the CONDITIONS for a statement might indicate when a statement applies, such as during certain weather conditions, at a set time, or at particular step in some process. Likewise, the CONDITIONS might indicate where a statement applies, such as a particular jurisdictional area. If an institutional statement does not specify particular variables, the default value for the CONDITION is in all situations at all times and in all places covered by that rule, norm, or strategy. Thus like the ATTRIBUTE, the CONDITION component always has some value in it even when the institutional statement fails to overtly specify it.

The CONDITIONS component in the first example refers to the state of Arizona, since the institutional statement refers to a state specific regulation. The CONDITIONS component in the second example indicates that a valid I.D. needs to be provided when the establishment where liquor is bought requests this. The strategy in the fifth example applies when a telephone call is disconnected. The third and fourth examples do not specify specific CONDITIONS; therefore, we assume that the rules apply for Maine fishers and microwave users under all circumstances. Note that conditions often apply to physical reality—i.e., when a call is disconnected. However, conditions are often specified by scope rules that restrict choices to very specific conditions.

11.2.5 OR ELSE

The final component of the institutional syntax is the consequence that an institutional statement assigns to detected noncompliance with the other components of the statement. In some cases, the OR ELSE specifies a range of possible sanctions if a rule is not followed. Individuals in the community know that if they violate a rule, they face the probability that a sanction in a specified range will be applied and that others in a similar situation face the same range. Only rules include an OR ELSE. This component, consequently, plays a crucial role in discerning what a rule is and how rules differ from other institutional statements.

Description of sanctions for breaking a rule are a common type of OR ELSE statement, but the OR ELSE may take other forms. The OR ELSE might also shift the DEONTIC assigned to some other action. For example, a violator might be forbidden to vote or engage in some other action that would otherwise be permitted. The OR ELSE might also shift the DEONTIC assigned to some

activity for an individual from permitted to obligatory. The violator might be required to allocate resources to a public jurisdiction (i.e., pay a fine), or another actor might be required to check on the violator. Those actions might be permitted under all other CONDITIONS, but obligatory when the CONDITION of a violation of the rule is met.

Although the OR ELSE often refers to physical punishments, the OR ELSE may also involve institutional actions, such as taking away a position or refusing to accept an amendment. For example, one of the rules governing the amendment process may state that legislators with [ATTRIBUTES][must][take a particular action][when voting for an amendment][OR ELSE—the amendment fails].

Three qualifications must be met for an OR ELSE to exist. First, the consequence stated in the OR ELSE must be the result of collective action. A collective decision must have been made in a relevant collective-choice arena to determine the consequence. Hence individual revenge is not a valid component of an OR ELSE statement. Second, the threat in the OR ELSE component of a rule must be backed by another rule or norm that changes the DEONTIC assigned to some AIM, for at least one actor, under the CONDITION that individuals fail to follow the rule. Often the actions threatened in the OR ELSE are forbidden under most CONDITIONS (e.g., imposing a fine, incarcerating a citizen, or taking someone's livestock and putting them in a village pen). The prescription backing the OR ELSE makes these actions permitted or required under in the CONDITION that someone breaks a rule.

Third, in order for an OR ELSE to exist, a prescription must affect the constraints and opportunities facing an actor or actors with the responsibility of monitoring the conformance of others. The actors who monitor frequently sanctioned nonconforming actors may only report nonconformance to someone else responsible for sanctioning. We do not consider government sponsorship to be a necessary condition for a statement to include an OR ELSE. Many self-organized, communal, or private organizations develop rules that include (1) sanctions, (2) another rule or norm that changes the DEONTIC assigned to some AIM for at least one actor if that individual fails to follow the rule, and (3) a norm or rule (a sanctioning prescription) that affects the constraints and opportunities facing an actor or actors who take the responsibility to monitor the conformance of others to the prescription (a monitoring prescription).

Turning again to the example of institutional statements listed above, the first three examples appear to contain an OR ELSE. Of course, we would want to check to be sure that there are rules or norms regarding monitoring and sanctioning that back the stated OR ELSE. For example, the potential punishment for fishers who put traps in a different territory is an OR ELSE only when rules or norms accepted in that harbor prescribe others to monitor and to employ the sanctions defined in the OR ELSE. Without the establishment of positions with the authority for monitoring and sanctioning, phrases that contain the words "or else" fail to constitute an OR ELSE that distinguishes an institutional statement as a rule as defined herein.

Institutional statements with content in the OR ELSE slot, then, are institutional statements that add information to the action situation about what will happen if a participant violates the prescription. The rule on producing a valid I.D. indicates that participants who violate this know that if he or she violates the rule they will face the consequence and cannot buy alcohol. In the first institutional statement, children younger than 10 years of age do not get a hunting license as a consequence of not meeting the CONDITIONS.

Compare the information about the consequences of the marriage rule to that in the microwave example. The sign on the microwave does not provide any specific information about what will happen to a participant who chooses to ignore the norm and leave a puddle of soup at the bottom of

the microwave. Office workers seeing the sign on the microwave have only information about their own internal costs and benefits of following the norm and their beliefs about how others in the office are likely to respond when they open the door and see the crusty soup spill there.

The OR ELSE component of a rule is frequently linked to a CONDITIONS component that specifies the number of times that a rule has been violated. The range of sanctions is likely to be lowest when someone has committed their first offense against a specific rule. A different rule, specifying a more stringent range of sanctions, will then be applicable if that individual has committed a second, or a third, or more offenses. Many rules against drunk driving use this form of graduated sanctions and increase the sanction for this offense substantially for second and third offenders.

11.3 How to use the grammar of institutions?

In the coming chapters we will discuss various examples of how to use the grammar of institutions to analyze concrete cases. You, like Kyle in South Park (http://www.southparkstudios.com/full-episodes/s15e01-humancentipad), may not be used to reading the terms and conditions of new purchases but it is probably a good idea to do so when the costs of not reading them may be high. At a minimum reading terms and conditions is a good exercise from the perspective of learning to use the grammar of institutions. What attributes of the consumer are specified, what are the conditions and the aims. What are the consequences, if any, if the conditions are not met?

Figure 11.3: South Park

When you look at concrete examples of norms and rules you experience every day, you probably will find that there are no explicit consequences. Does that mean that these statements are always norms? Absolutely not. Many statements are imbedded in regulations at higher organizational levels. So, many rules add special conditions to already existing collections of rules. Not all rules that are involved in taking a course are explicitly stated in the syllabus. There are many rules at the college or university level that hold for many courses and which are not explicitly stated in the syllabus that are *implied* by the fact that students are taking a class. Furthermore, universities need to meet regulations imposed by the state and the federal government. These obligations impact the syllabus, but are not stated. If all relevant rules were stated for a class, the syllabus would be 50 pages long. In fact, the syllabus mainly focuses on the specific rules related to the specific course. Thus, to be fully aware of the structure of an action situation, participants may need to be aware of several different collections of rules and how they are nested.

11.4 Critical reflections

In this chapter you learned about a systematic way to analyze statements that can be classified as strategies, norms and rules. Strategies do not include a specification that some behavior may, must, or must not occur. The difference between rules and norms is the explicit statement of the consequences if a rule is not met so that a third party can enforce the rules.

11.5 Make yourself think

1. Look at the terms and conditions of a recent purchase. What are the rules and norms? What are the consequences if a rule is not followed?
2. What are rules and norms in the syllabus of the course you are following?
3. Are you aware of all the rules that *might* apply in a given action arena you are in frequently? Under what circumstances would it be reasonable to not know the "letter of the law" governing the situations you may be in often?

11.6 References

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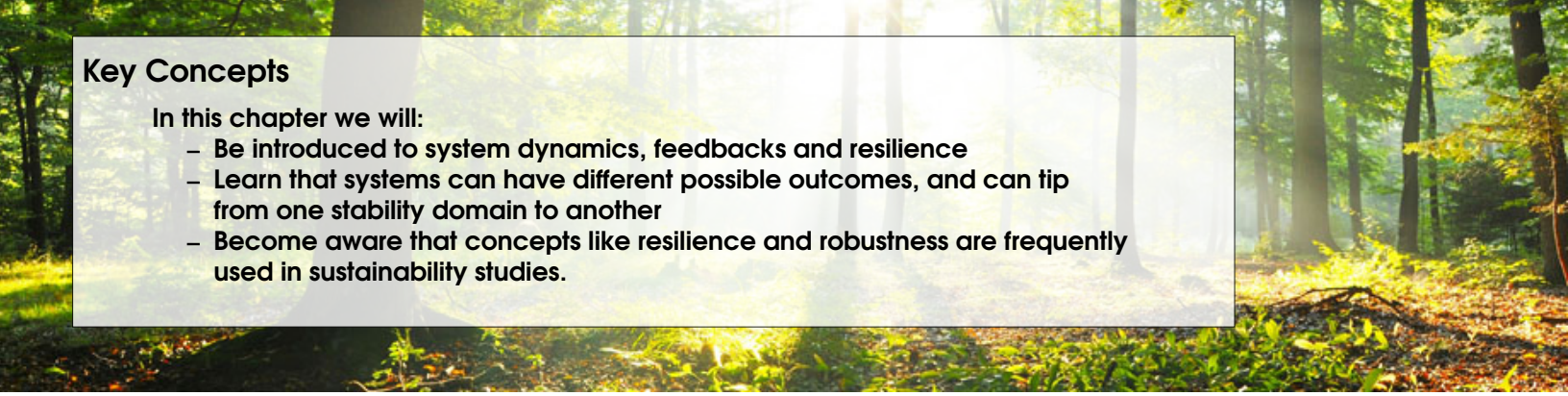
Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.

Part V

A Systems Perspective



Key Concepts

In this chapter we will:

- **Be introduced to system dynamics, feedbacks and resilience**
- **Learn that systems can have different possible outcomes, and can tip from one stability domain to another**
- **Become aware that concepts like resilience and robustness are frequently used in sustainability studies.**

12 — Feedbacks and Stability

Flipping Lakes

Lakes are islands on land. Lakes are a favorite study object for ecologists since they are relatively self-contained ecosystems in which a range of plant species, fish species, and biochemistry interact. There are many different types of lakes and one can study which attributes of lakes generate different patterns of species abundance. One of the key areas of study is the process of eutrophication. If a large quantity of nutrients enters a lake due to runoff from the heavy fertilizer use on nearby farms, the lake water can suddenly flip from being chrystal clear to looking like pea soup. This is an example of an ecosystem that can exhibit different long-run patterns of species composition (or "states"): a clear lake with little algae and a green lake dominated by algae (Figure 12.1).

One ecological mystery that has interested limnologists for a long time is why lakes suddenly flip from a clear blue to pea soup. The study of resilience of ecosystems has provided some insights on why this happens. Lakes, especially shallow lakes, have tipping points related to the amount of nutrients they can process beyond which the lake flips. When a lake turns to pea soup, it is not only less attractive to swimmers, it also creates an environment with reduced biodiversity that favors weeds and limits the number of fish species. We know that we need to control nutrient use to avoid creating undesirable states in nearby lakes, but the use of fertilization for agriculture also has benefits. Understanding how to avoid flipping the clear lake system into pea soup is critical and can provide lessons for other types of problems. For example, we may want to avoid pushing the climate system toward dangerously rapid change, or causing coral reefs to flip from a healthy state with many fish species to one dominated by slimy weeds.

Figure 12.1: On the left is an example of a crystal clear blue lake, while on the right you see a eutrophic lake.

12.1 Introduction

In this chapter we discuss systems thinking and the concept of resilience. **Systems** are composed of component parts which interact with each other. For example, a herd of cows consumes grass from a

pasture. The component parts in this case are the herd of cows and the pasture. As cows consume grass the biomass from the pasture is reduced. On the other hand, the cows produce manure which fertilizes the pasture leading to an increase in biomass. This simple example illustrates how the component parts interact and cause each other to change. Another example is a person controlling the temperature of the water while in the shower (Figure 12.2). If the person wants to increase the temperature, she will increase the volume of hot water and/or reduce the volume of cold water. There might be some delay between when faucet is adjusted and hot water actually begins coming out of the faucet. An impatient person might open the hot water faucet too much and burn herself. Getting the right temperature requires that the person adjusting the faucet react appropriately to the information gathered from the shower (water temperature) in order to adjust the controls (opening the hot water faucet) appropriately. The interaction between the person and the shower is a system based on feedbacks. The notion of feedback is illustrated in Figure 12.2. The two component parts of the system, which are often represented as "state variables," are here represented by boxes and the interactions between the variables by arrows. You can imagine signals flowing in a circle. A temperature signal flows from the shower water to the person who translates it into a position signal for the faucet knob, and the cycle begins again. This cycling of signals is the reason for the term "feedback loop."

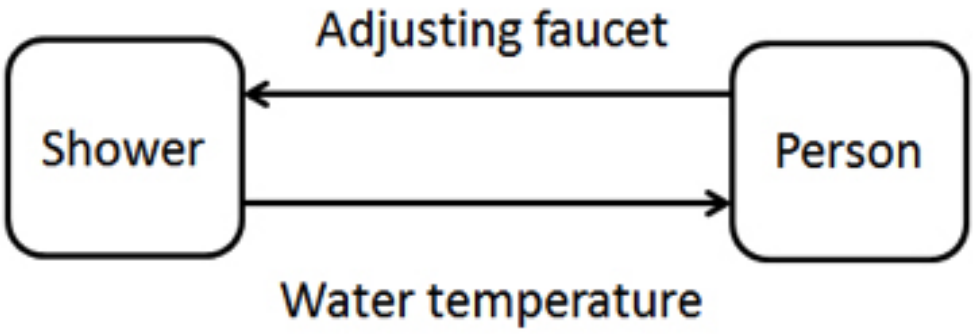


Figure 12.2: Hot water faucet adjustment from a systems perspective.

In the language of "state variables," a change in variable A causes a change in variable B which subsequently impacts variable A again. Feedbacks can be positive or negative (Figure 12.3). A positive feedback occurs when a change in one variable, after going through the feedback pathways, returns to induce an additional change in that variable *in the same direction* as the original change; if the additional change is in the opposite direction, we call that a negative feedback.

An example of a positive feedback is money on a savings account. As long as you don't take any money out of a savings account, the money will generate interest which is put back on your account and the next year you earn interest over a larger sum. Hence the interest you earn on interest from the previous year is an example of a positive feedback. An example of a negative feedback is the shower example. If the water is too hot, you reduce the amount of hot water, and if it is too cold you increase the amount of hot water in order to push the temperature toward your preferred value or **set point**. Here, "negative" refers to deviations away from the set point. The person generates negative feedback when they respond to the **positive deviation** by adjusting the faucet to **reduce the deviation**.

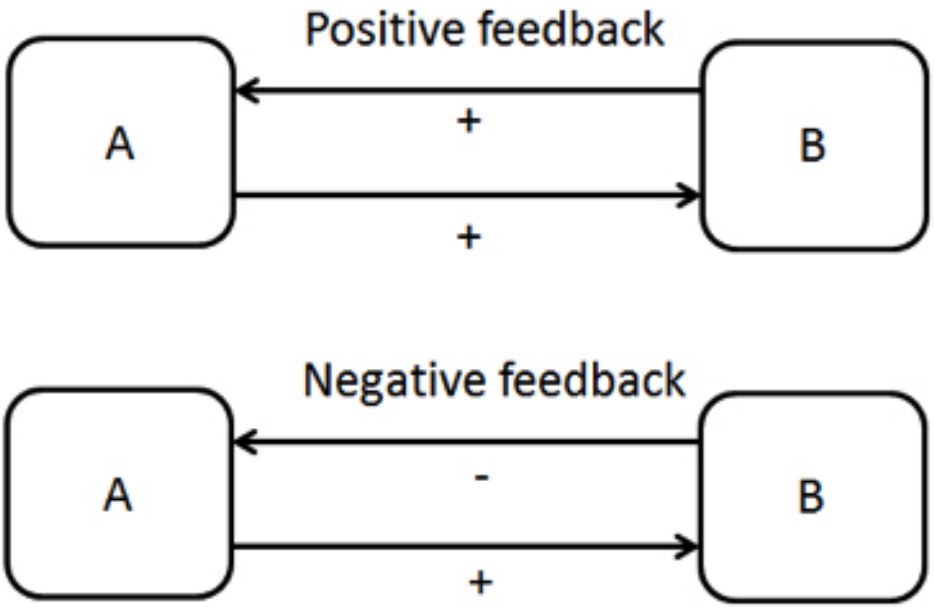


Figure 12.3: Examples of systems with positive and negative feedbacks.

If we look back at Figure 2.5 on the Institutional Analysis and Development Framework we can also consider the IAD a systems representation of governance problems. The outcomes of the action situation feed back into the contextual variables or directly into the action situation again. In this chapter we discuss the systems perspective more explicitly since there are a number of related concepts that are increasingly used in sustainability studies.

12.2 Resilience

Humans are part of a system of human-environmental interactions. Humans influence the rest of the system by appropriation of resources (i.e., removing system elements), pollution (i.e., adding system elements), landscape alterations (reconfiguring system elements), etc. There are characteristics of systems that help us to understand how they may evolve over the long term and how they are affected by these human activities.

Consider a young forest where the trees are small and there is sufficient light and nutrients for the trees to grow. The trees in the forest initially grow fast and the forest starts to mature over time. The growth rates of the trees slow down when the trees get bigger, block the sunlight for each other and compete for nutrients. Add to this idealistic description of tree growth the fact that forests cope with many types of disturbances such as pests, forest fires, and tornados and this situation becomes more complicated. If a forest experiences a fire why does it cause more damage in some forests than others? How does management of the forest influence the size of forest fires? And if forest fires are natural phenomenon, shouldn't we allow them to burn freely? These are major challenges for agencies that manage forests. Since 1944, the U.S. has used an icon named Smokey the Bear to

promote the suppression of fires. But it is one thing to try to prevent humans from starting fires, it is quite another to suppress all fires.

In fact, due to the suppression of forest fires, forests in many places in the U.S. have built up large fuel loads. This fuel consists of dead wood that is not removed by regular forest fires. This has consequences. When forest fires happen in forests where fuel has accumulated for decades, fires are intense and burn all trees, young and old, and even the soil. As a result, the forest will not recover. This is in stark contrast to forests that have frequent, smaller, lower intensity fires that regularly reduce the fuel load (hence, only small fires can burn). These types of files do not burn all the trees or harm the soil, therefore forests can easily recover. Hence too much suppression of forest fires can reduce the resilience of forests such that they cannot recover from the disturbance of an inevitable fire.

The concept of resilience in ecological systems was first introduced in 1973 by the Canadian ecologist C.S. "Buzz" Holling in order to describe the persistence of natural systems in the face of disturbances such as fires and pest outbreaks (Figure 12.4). A single system can have multiple types of states, for example a lake can be either clear or green and murkey, a rangeland can have a mix of healthy tall grass and with a few trees and shrubs, or it can be covered with noxious weeds. If a system state is resilient, the system remains in that state even if it is exposed to disturbances. If a system state loses it's resilience, for example due to fire suppression, decades of nutrient loading in lakes or overgrazing a rangeland, it may not be able to recover from a even a small disturbance, which would cause it to flip into a very undesirable state.

Figure 12.4: C.S. "Buzz" Holling.

The concept of resilience can be applied to many ecological systems. As discussed above, ecosystems often have multiple stable states. With the term stable state we refer to a certain configuration of the system—such as a healthy productive ecosystem with a lot of biodiversity—

which can cope with variability such as rainfall, storms, droughts etc. An alternative stable state could be an eroded unproductive ecosystem. But there are limits to the size of the disturbances a system can cope with while in a particular stable state. If the system is in a desired stable state—such as the healthy productive state—we often want to keep it like that. Resilience can be defined as the magnitude of the largest disturbance (e.g., fire, storm, flood, nutrient shock) the system can absorb without transforming into a new state. The problem is that human activities can reduce the resilience of the system and make it more vulnerable to smaller and smaller disturbances such that it flips to another stable state (Figure 12.5). If a system is in an undesirable stable state we may want to restore the ecosystem but such states might be very difficult to get out from. Those undesirable states might be very resilient.

Figure 12.5: A representation of a system, the fish, that flips from one state to another state, the bowl.

Rangelands, found in arid areas all over the world, are another example of systems with multiple stable states. To illustrate the possible multiple stable states we focus on the example of Australian rangelands. When Europeans came to Australia they started to use rangelands to raise sheep and cattle. Before European settlement, natural grazing pressure was the result of native herbivores such as kangaroos, wallabies, and wombats and was relatively low. When settlers added sheep and cattle to the system, the grazing pressure was increased significantly. Moreover, European settlers installed watering points (simple troughs fed by water pipes) in the landscape to provide water for their sheep and cattle. Not only did these watering points benefit the sheep and cattle, they also benefitted the kangaroo population which further increased grazing pressure.

In many areas of Australia, the properties (ranches) are very large and the density of grass is very low. As a result, the impacts of overgrazing may not be directly visible in the short run. Figure 12.6a shows an example of a healthy grazing area, which looks quite different compared to the green meadows in Europe. Nevertheless, the farmers made a good living out of this production strategy.

But they not only increased the grazing pressure, they also suppressed fire. As a consequence, woody weeds started to blossom (Figure 12.6b) which outcompete the grass and make the landscape useless for sheep farming. It will take decades before the woody weeds will disappear through a natural cycle, and it is too costly (given the size of the properties covering hundreds or even thousands of acres) to remove the weeds mechanically. As a consequence, a significant area of Australia's grasslands have now flipped from a grass-producing sheep-supporting landscape into a woody, weed-dominated wasteland.

Figure 12.6: On the left we have a typical Australian grassland (a). The landscape on the right shows a pasture dominated by the invasive species Scotch thistle in south eastern Australia (b).

12.3 Tipping points

In this section we focus on a specific element of systems with multiple stable states, namely tipping points. How can we explain that systems suddenly change their behavior and change their configuration? Remember that systems consist of components that are connected via feedbacks. Those feedback relations can change. For example, grass can compete with woody shrubs in rangelands when grass has a particular density. When the ratio of grass to woody shrubs crosses a certain threshold, grass cannot compete anymore, and woody weeds take over. This threshold in the ratio of grass biomass to woody shrubs is the tipping point. Ecological systems are not the only systems that have tipping points. We can find tipping points in social systems as well (e.g., a peaceful protest flips to a violent riot). In his bestselling book, Malcolm Gladwell (2000) uses the example of the New York subway system. When there is a lot of graffiti on the subway vehicles and trash on the ground, people are more likely to be polluters. In the 1980s, the city government started cleaning the subways every day whenever they noticed new trash and graffiti. In a clean subway car, people are less likely to put new graffiti or throw trash on the ground or on the floor of the subway car. The feedback dynamics have changed, and cleaner subways cars stimulate cleaner behavior—an example of a positive feedback.

How do we know we are near a tipping point? This is a critical question, but unfortunately we cannot answer it very well. A tipping point is something we cannot directly observe—it is hidden until we pass it. But if the only way to discover it is to pass it, and the point of discovering it is to **not** pass it, we are in a bit of a quandary. In fact, we only observe certain features of the system that are the indirect result of getting **near** a tipping point. One feature we can exploit is the fact that near a tipping point, somehow the system is "balanced" (see Figure 12.7). When the system is balanced, very small disturbances persist for a long time. Imagine a marble on a perfectly flat surface. The tiniest push will make the ball roll for a long time. Imagine, on the other hand, a bowl with steep

sides, with the marble resting at the bottom of the bowl. If you give the marble a push away from the bottom, it will return rather quickly and stop moving. Thus, as systems approach tipping points, the rate at which they rebalance themselves after a small disturbance slows down. This is called "critical slowing down" and is one method (albeit an imperfect one) to discover whether a system is nearing a tipping point. Discovering when complex social and ecological systems approach tipping points is extremely difficult, and remains an active area of research.

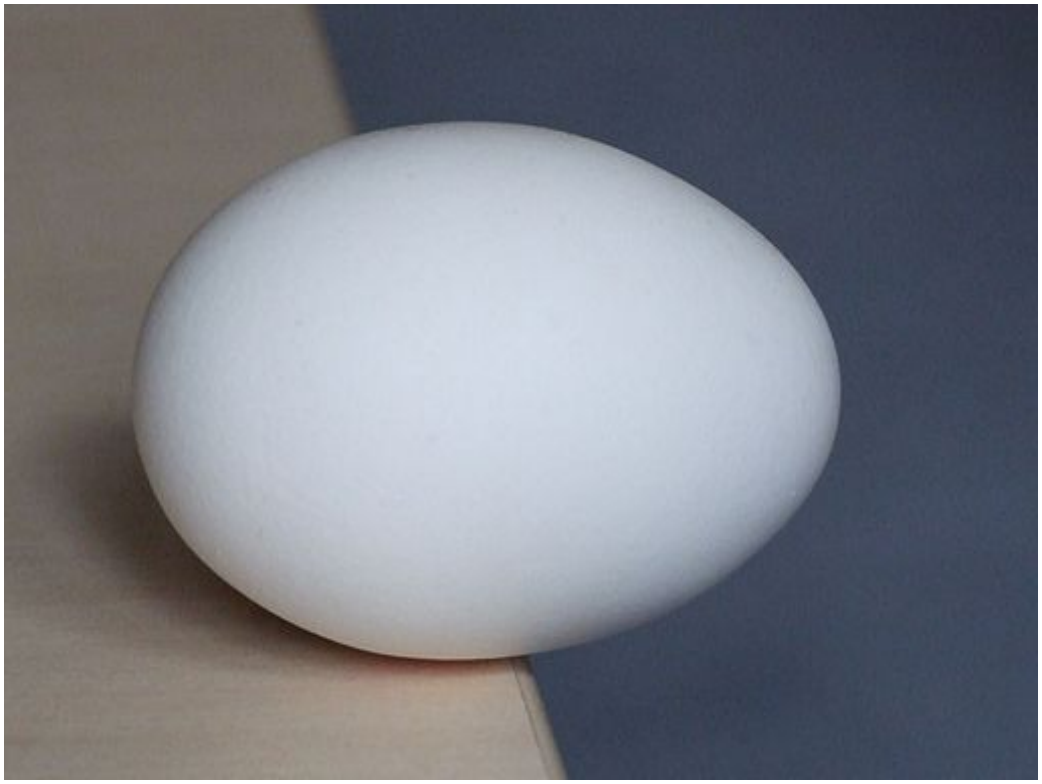


Figure 12.7: An egg balancing on an edge. How much disturbance will cause the egg to fall and experience a new stability domain?

Along with the increasing use of the term resilience in sustainability debates we also see the use of the term robustness. What is robustness and how does it differ from resilience? The concept of robustness comes from engineering and is used to design systems. For example, engineers develop control systems for airplanes such that the ability of the airplane to fly is "robust" to mechanical failures, turbulence, wind shear, etc. In their design of a robust airplane, engineers include various backup systems to avoid the situation in which the "system" (i.e., the plane and the people in it) flips from cruising at a constant altitude of 30,000 feet (10 km) to a free fall. But engineers also know that there are costs related to robustness and tradeoffs need to be made.

Do we build a wall 10 meters high around New Orleans to avoid damages from the next major hurricane? As we design systems to reduce our sensitivity to damages (i.e., to be robust) from disturbances, we have to make choices about what disturbances to consider. To be robust to one type of disturbance may create vulnerabilities to other types of disturbances. For example, utilizing concrete canals instead earthen canals for irrigation may reduce the number of wash outs, but may also reduce the ability of farmers to be adaptable and spatially reconfigure water flows using

temporary mud walls in earthen canal systems to deliver water to the farmers' fields under variable circumstances.

Engineers argue that systems can be robust, yet fragile. They can become more robust to big fires but more vulnerable to small fires. Hence difficult choices have to be made.

12.4 Managing performance of systems

In our description of the IAD framework we discussed evaluation criteria associated with various outcomes. Interactions between the participants in the action arena lead to particular outcomes. Those outcomes are evaluated somehow. For example, did the participants achieve their goals? Are policy targets reached? Did the interactions lead to a fair allocation of resources? Based on the evaluation of the outcomes, the interactions in the action arena continue, and/or participants learn and change the rules-in-use. This chapter is about systems, and systems are about feedback and control. As such this chapter provides a more general perspective of the IAD framework.

Let's discuss the example of the IAD framework applied to taking a course (Figure 2.6). The interactions of the participants lead to a grade over the course of the semester. The specifications on how the grade is calculated are specified in the syllabus. When the professor and the students generate new grade information after an exam, they evaluate this information. This can lead to a continuation of the interactions in the action arena, but may also lead to a change in the attributes of the course participants (some may drop the course, or start studying more), or a change in the rules-in-use (the professor makes adjustments to the course material for the remainder of the course).

An example for natural resources is the use of groundwater. A city may use groundwater to provide its residents and industries with the water they need. The ground water is replenished when it rains. If in the long term less water is extracted than is replenished, the groundwater level remains the same. However, a problem in many urban areas is that water demand is increasing rapidly, while the supply of water remains the same. As a result, the groundwater level will decline. If one measures the ground water level on a regular basis one will observe this decline. How will the city government respond to this decline? At which level of groundwater decline will new policies be implemented (i.e., changes in the rules-in-use)? Will those policies focus on increasing supply or reducing demand? If the city will not respond in an adequate way, residents may revolt against water shortages or higher water prices, and may even leave the city (this may seem an unlikely scenario to many readers, but this actually occurred in the year 2000 in Cochabamba, Bolivia). Every response may generate new or expose existing hidden fragilities. For example, reducing water demand may cause problems with the pipes, such as solid waste building up when the flow rate of water through the pipes is reduced. Another example is that importing of water, such as bringing water from the Colorado river via canals over hundreds of miles through the desert to the city (see Figure 5.5), makes a city vulnerable to changes in climate in other parts of the country.

Managing a dynamically changing system is difficult. We can control the temperature of our shower at home pretty well, but may burn ourselves if confronted with a different shower in a hotel during travel. What if lots of people are trying to adjust the faucet at the same time? As a thought experiment, consider a bunch of participants in the shower. First a goal, the desired water temperature, has to be defined through a collective choice process. Will all participants have a say, or are only certain participants in the action arena allowed to define the goals? Suppose there is a common goal, how will information about water temperature be used to adjust the faucet. Not all participants will receive the same feedback since not all participants can be under the showerhead. Do the people who adjust the faucet get reliable information from those who experience the hot water

from the shower? This example shows the complexity of controlling a dynamic system when there are different participants who have different goals and positions. The institutional arrangements can enable or hinder the ability of groups to reach long term goals.

Earlier in this chapter we mentioned that it is very difficult to know when a system is reaching a tipping point. We only know it for sure once we have passed it. How can we manage complex systems if we have incomplete information about the system? Scholars who have studied resilience and robustness of systems come to a number of insights that might be helpful for managing systems:

- Maintain diversity within the social and ecological components of the system. This includes biodiversity, but also institutional diversity. This diversity contains alternative solutions expressed in DNA or institutional arrangements. Avoid monocultures. In agriculture, a crop may be affected at a global scale if all seeds come from the same source and this particular variant becomes vulnerable to a pest. Likewise we don't want to have the same institutional arrangements in all jurisdictions. With institutional monocultures we cannot learn how others have addressed a similar problem in a different way.
- Maintain modularity of systems. Nobel Laureate Herbert Simon used the example of the watchmaker to illustrate the importance of modularity. Suppose a watch consists of a 1000 parts. One approach to watch design is to assemble all 1000 components in one sitting. If the watchmaker is disturbed or makes an error during the assembly process, she has to start again from scratch. Another design has modules and the watchmakers can assemble the modules, and then put the modules together. If a disturbance happens the watchmaker only needs to recreate one module. Modules also relate to the governance of social-ecological systems, and therefore we have states, counties and watersheds as units of governance in which new technologies and policies can be experimented with, without impacting the rest of the system.
- Finally, it is important to keep options open. Maintain redundancy, by which we mean that it is important to maintain some breathing space for the system. If everything is organized in a very efficient way, a disturbance could eradicate a keystone species, a charismatic leader, or the one source of revenue. It is important to have some fat in the system so that a disturbance can be absorbed. Have two operators of the energy distribution system so that the system can still continue if one of the operators is sick. Have multiple suppliers of energy so that a cloudy day reducing solar energy will not lead to a blackout of the energy system. .

Managing the performance of a system is very hard. It requires practice, continuous learning, and maintaining diversity, modularity and redundancy. To close this chapter, we relate the concepts of resilience and robustness back to sustainability.

12.5 Resilience, robustness, and sustainability

In recent years the concepts of resilience and robustness have been increasingly used in the debate about sustainability. How do they relate to each other? Sustainability refers to a goal one aims to achieve. Sustainability guides the discourse on the interaction between human societies and the environment. There are many dimensions of sustainability, varying from avoidance of depletion of natural resources, avoidance of inequality and stimulation of quality of life for everyone and striving for a just society. Resilience and robustness ideas can be used to define system properties that may help decision makers to achieve sustainability. Robustness focuses on feedback systems with clearly defined boundaries. Robustness comes from engineering and robust-control systems. It can be

used to address questions about how to control a system to reach a target, such as sustainability? Robustness enables us to think about decision making, which information to use, how fast to respond to changes, and to think about trade-offs in decisions to be robust to certain shocks but not to others.

Resilience provides a framework to think about how multiple systems, each operating at their characteristic temporal and spatial scales, interact across scales. Human decision making can affect the resilience of a system by changing the shape of a particular stability domain. This can be intentional with a goal, for example, catalyzing a transformation of a fossil fuel economy towards a solar powered economy. Hence, resilience of a system in a particular stability domain is not always desirable and human activities can shape the long term dynamics of the system.

12.6 Critical reflections

With a systems perspective we consider the components of the system and their dynamic interactions. The IAD framework we discuss in this book is a systems perspective of human behavior, institutions, and the environment in which they are embedded. Systems also have characteristics such as resilience and tipping points, which we can observe in social as well as ecological systems.

12.7 Make yourself think

1. The next time you take a shower, reflect on your ability to control the temperature.
2. Do you know an example of a resilient system?
3. What would be an alternative outcome for that system?

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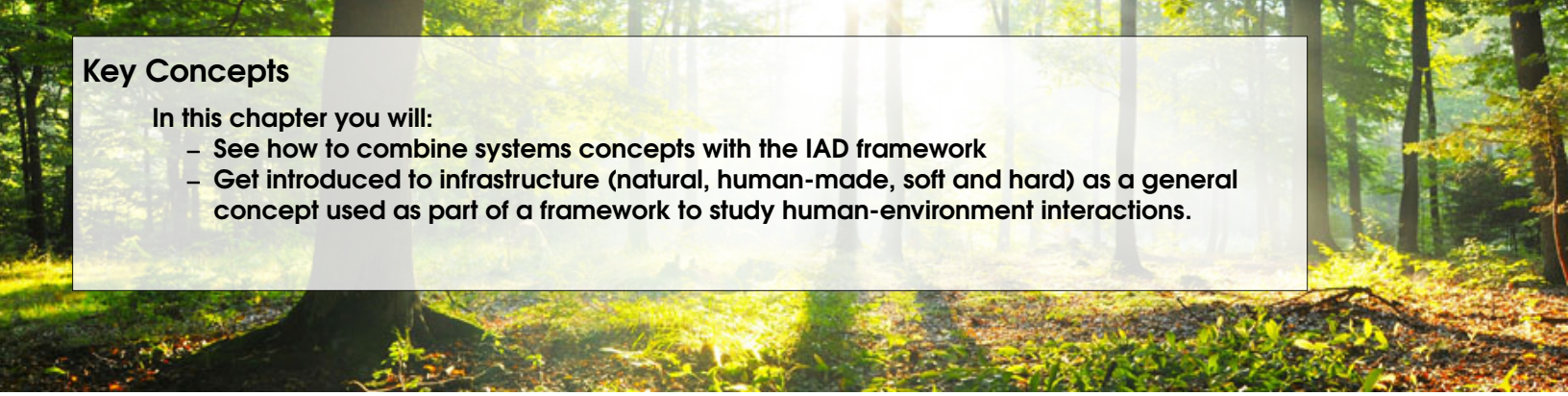

Key Concepts

In this chapter you will:

- **See how to combine systems concepts with the IAD framework**
- **Get introduced to infrastructure (natural, human-made, soft and hard) as a general concept used as part of a framework to study human-environment interactions.**

13 — Coupled Infrastructure Systems

Natural Infrastructure

When one of the authors visited Andhra Pradesh, India as guest of the NGO Foundation for Ecological Security (FES) he was informed of the progress communities in that region had made to restore their natural infrastructure. Over the years, grazing of livestock and collection of fuel wood had led to deforestation of the nearby hills. As a consequence, water was not being captured by the landscape and groundwater system during rain storms, but instead, immediately began flowing down the hills into drainages (small streams) and away from the villages. This has contributed to a shortage of water in the nearby villages, which also face severe poverty. As part of the Mahatma Gandhi National Rural Employment Guarantee Act, rural communities can receive funding to pay wage labor up to 100 days a year per person to contribute to public works. FES helps communities to compete for this funding for restoration of their degraded ecosystems. As a consequence, the community not only generates income, but has also improved the capacity of their land to capture water and thus increase the productivity of their land in the long term.

Figure 13.1: Deforested hill in Andhra Pradesh, India.

13.1 Introduction

In this chapter we will discuss an extension of the IAD framework that includes some of the insights from systems science. Furthermore, it incorporates our long-term experience with studying current and historical irrigation systems around the world. We view irrigation systems as a model for many problems societies experience just as the fruit fly is used as a basic model in genetics. By this we mean that studying collective action problems in irrigation systems will teach us a lot about solving collective action problems in many other societal contexts. Moreover, we argue that many societal problems can be studied from a coupled infrastructure perspective.

With infrastructure we refer to collective structures that enable systems to produce certain outcomes. Basic examples include roads, bridges, and electricity distribution systems, as well as internet communication protocols and computer software. We will discuss different types of infrastructure in the next section in more detail. A basic aspect of infrastructure is that it requires investment to create and maintain. In the case of **public infrastructure** (roads, dams, electrical grid,

electromagnetic spectrum) that is shared, society must **invest collectively** to create and maintain the infrastructure. Who pays and who can use the infrastructure are critical collective choice questions. Are new roads paid from a tax on gasoline or by all tax payers? Is the road open to everyone, or only for those who can pay the toll?

13.2 Different types of infrastructure

Infrastructure is a general concept and can be described in physical terms or in economic terms. The most natural definition is the economic one: infrastructure is a collection of materials (e.g., machines) and information (e.g., knowledge about how to use machines) that can produce a stream of materials (food, cars, houses) and information (music, movies) that society values. The second key feature of infrastructure is that it requires investment (a so-called opportunity cost) to produce and maintain (machines must be built, and maintained; without practice, skills decline) and infrastructure typically has little value in its own right (farm machinery isn't exciting in its own right—its main value comes through its capacity to produce food). There are different forms of infrastructure that come together to produce output (you can't operate farm machinery without knowledge) and we discuss these different forms of infrastructure in the following sections. They can all experience collective action challenges in order to be created and/or maintained.

13.2.1 Hard infrastructure

With "hard infrastructure" we are mainly referring to human-made infrastructure such as roads, irrigation systems, and nuclear power stations. Basically hard infrastructure enables the production and distribution of clear fresh water, waste, energy, products, people, and information. We have infrastructure to move people in cars, trains, on water, in the air, via rail and road, and by foot and on bicycles. To facilitate the movement of people, we need energy which can be produced by various types of power generation plants or processing of fossil fuels. This energy needs to be distributed through the electrical grid, or in the case of gasoline, through a combination of trucks and roads, in order to be useful.

As you can see, hard infrastructure provides the key underlying structure for society and, as such, is too large to be produced by individuals (e.g., few individuals are wealthy enough to build the Golden Gate bridge on their own—it cost around $340 million in today's dollars). It must be collectively produced and, as a result, various types of collective action problems must be solved in order to produce functional infrastructure. Who will create the infrastructure, and where will it be located? After it is created, who is responsible for maintenance? The difficulty these problems pose is evidenced by the fact that infrastructure in the U.S. is failing. Examples include falling bridges, blackouts and flooded neighborhoods. According to the website http://www.infrastructurereportcard.org/ the U.S. needs to invest 3.6 trillion dollars over a five-year period to maintain the function of its infrastructure, which is more than $2,000 a year for each person living in the U.S. over that period. We discuss in the next section some of the collective action problems. First we want to discuss some other types of infrastructure.

13.2.2 Soft infrastructure

With soft infrastructure we refer to the human-made "instruction" for using other types of infrastructure. Instructions require knowledge of how systems work and thus involve significant investment. They are also absolutely essential to generate valuable outputs. The computer (hard infrastructure)

on which this this book was written is useless without software (soft infrastructure). In this sense, soft infrastructure can be thought of in general as the instructions by which society is run (across all levels of organization from the individual, to neighborhoods, to counties, to nations, and the United Nations). One type of soft infrastructure essential to the topic of this book is that of "institutions." Recall that institutions are rules (instructions) that structure repeated interactions between people. To be effective, these institutional arrangements must be combined with other types of infrastructure (i.e., all types of infrastructure necessary for organizations to function such as buildings, communication, transportation) which create, implement and monitor the rules. Examples include the rules by which local government function, the protocols by which crime labs and emergency services are run, the constitutional law upon which the supreme court bases its decisions, and the tax law by which the tax collector functions. Soft infrastructure enables societies to solve collective action problems and coordinate their activities.

13.2.3 Natural infrastructure

This is the hard infrastructure that is not man-made but still is critical for society. Wetlands absorb and filtrate water, trees capture water and reduce erosion, and bees pollinate flowers. Some people may use the term "ecosystem services" to refer to natural infrastructure but those services only exist within an anthropomorphic context. In our view ecosystems are forms of infrastructure and humans can limit or enhance the capacity and performance of those infrastructures through the use of other types of infrastructures. That is "services" only flow in coupled infrastructure systems! Without knowledge of how to hunt or which plants are useful (human infrastructure—see below), etc. ecosystems do not produce services.

13.2.4 Human infrastructure

Knowledge is an essential element of any productive activity. Whether it is the knowledge of how ecology works for the hunter-gatherer, knowledge of seed varieties and soil characteristics for the agriculturalist, knowledge of 2-D projection for the painter, knowledge of stone for the sculptor, knowledge of machinery for the industrialist, or knowledge of kinesiology for the athlete, knowledge is essential. Knowledge is itself infrastructure because it requires investment and can produce valued outputs (when combined with other types of infrastructure). Right now, you are investing in developing your human infrastructure. The physical manifestation of human infrastructure is the neural network in each of our brains. These neural networks require great effort (investment) to train to retain information and problem solve. In fact, the capacity of our brains to do this makes us uniquely human. One might argue that we are also natural infrastructure. This is correct, but for analytical purposes it is useful to define this as a special class of natural infrastructure called human infrastructure.

13.2.5 Social infrastructure

Social infrastructure refers to the relationships we have with others. These relationships (e.g., trust) are essential for our economy to function. Imagine the number of times you needed help from a friend or relative to get something done. What would you have done without friendship? Hire someone? Think of the trouble of hiring someone to do something you would ask a friend to do. The "trouble" of relying on markets (to hire someone, you would need a labor market for "miscellaneous friend tasks") in economic jargon is "transaction cost." Social infrastructure reduces transaction costs. Metaphorically, social infrastructure is the grease that reduces the friction of human interaction

and allows the machinery of society to function. Further, building trust (either via friendships or professional relationships) is extremely time intensive (i.e., requires significant investment). Thus, because social infrastructure produces benefits and requires investment, it is infrastructure.

As mentioned above, to produce valuable outputs, multiple types of infrastructure must be combined. In fact, we argue that all types are necessary with the exception of social infrastructure in some very special cases. We will explore this point more below. But first, we consider the connection between collective action and infrastructure.

13.3 Collective action and infrastructure

There are a number of collective action problems related to the creation, maintenance, and use of infrastructure. One key problem is the question of who is going to pay for the creation of the infrastructure or, put another way, how will the cost be shared? Farmers in rural Nepal may pay by providing labor to the construction and maintenance of the irrigation system. In many western societies we have governments that collect taxes and use the resulting revenue to pay for the creation of infrastructure.

The regulations regarding who pays can lead to perverse effects. For example, in the U.S. the federal government pitches in to pay the majority of the costs for highways, while the local governments pay less than half the costs. As a consequence, local governments are often eager to increase the number of highways to promote economic development. The subsidizing of road expansion was instituted after World War II to stimulate road expansion to improve transportation and accessibility and, indirectly, economic development. A consequence of this policy is that roads are cheap for users and this enhances the demand for using them. One reason for the low price for using roads is the relative lack of maintenance, which is paid for by local governments. So, local governments want to improve economic performance to send signals to voters to get re-elected, but forget that roads must be maintained. This activity may generate short term benefits, but generates a long-term burden for tax payers. One way to generate more funds for road maintenance is though the "user pays principle" and to raise taxes on gasoline (an indirect way to charge drivers to use the roads). Of course, this a politically challenging proposition for elected officials who cannot afford to be seen raising taxes.

A second collective action problem for infrastructure is to define who gets access to its use. In many irrigation systems there is a natural asymmetry between the upstream and downstream users of the canal system. Farmers have to solve the collective action problem of how to deal with this asymmetry. They may create a rotation system to reduce the impact of asymmetry. When taxpayers contribute equally to the creation of the infrastructure, this does not mean that they all have access. Tax payers contribute to higher education, but not everyone who pays taxes has access to the knowledge infrastructure that is created. There are criteria for students to be admitted. The reason that societies invest in higher education is that everyone benefits indirectly by having a highly educated population (such as physicians, engineers and lawyers).

13.4 Coupled infrastructure systems

In this section we present an extension of the IAD framework that includes some of the specific problems related to interacting infrastructures. The framework was developed by Anderies, Janssen and Ostrom in the early 2000s to facilitate their study of irrigation systems. The notion of infrastructures creating the action arena are implicit in the IAD framework; the details are not explicit. The intent of

the Anderies et al. framework (the so-called Robustness Framework) was to make explicit how the different types of infrastructure discussed above come together to structure the "action arena." To introduce the framework we will focus first on a shared resource that is used by a number of resource users. This has been the canonical view for many of our small communities who interact with their resources. However, this raises the question of who creates the rules of how the shared resource will be used?

In this framework we explicitly include two levels of action arenas, namely the operational level and the collective choice level. The third component of the framework consists of the public infrastructure providers, who are the ones who create the rules for the resource users. In small communities all resource users might come together on a regular basis in the evening to discuss the challenges in governing their shared resource. Their might be a chair, a treasurer, and some other roles within the group of public infrastructure providers, but they are all resource users and thus have a stake in creating rules to improve the performance of using the common resource.

In larger systems, individuals represent other resource users, typically in committees that deal with provisioning of the public infrastructure. These representatives are often selected through a collective choice arrangement. Decisions by the committee about what types and how much public infrastructure is provided are also made using agreed-upon collective choice arrangements (e.g., Robert's Rules of Order). This could be the state forestry committee that makes decisions on how to cope (i.e., how to allocate resources) with invasive species and who set rules on property tax benefits for land owners who plant new trees. The general assembly of the United Nations is a more extreme example where each member, a nation, is represented by an ambassador in making policies at the international level.

In studies where the Robustness of Coupled Infrastructure System framework has been used, a common finding is that the link between resource users (mainly human and social infrastructures) and public infrastructure providers (mainly human, social, and soft human-made infrastructures) is a critical one. The bigger the distance, the less the practical knowledge (a particular type of human infrastructure) from resource users is included in creating institutional arrangements. A lack of practical knowledge may lead to policies that do not fit the reality that resource users experience and therefore policies may not be effective. On the other hand, local communities may not have the specialized knowledge (a different type of human infrastructure) needed to solve certain problems on their own, and therefore creating institutional arrangements where representatives of many localities are involved can be beneficial.

The fourth component of the framework is the public infrastructure which includes mainly hard and soft human-made infrastructures. The public infrastructure providers may have decided on new institutional arrangements, but they may need a bureaucratic apparatus to implement and enforce those rules. Tax collectors, property inspectors, and guards are all essential human infrastructure to implement the soft infrastructure of various types of coupled infrastructure systems. Canals, pipes, bridges, and satellites are part of the hard infrastructure of various types of coupled infrastructure systems.

The infrastructure could influence the resource directly, for example by improving the capacity of a landscape to capture water, or monitoring the state of the forest by remote sensing. The infrastructure can also interact directly with resource users, namely by assigning allowable actions (licensing), by monitoring the actions of resource users relative to allowable actions, or by providing information to users such as weather forecasts.

The framework (Figure 13.2) distinguishes four components, namely the shared resource system (natural infrastructure), resource users, public infrastructure providers and the public infrastructure.

We can integrate this with the IAD framework such that the interaction between the four components constitutes a set of action arenas at the operational (resource users) and collective choice (public infrastructure providers) level. The external context defines the biophysical conditions of the shared resource system and the public infrastructure, the attributes of and the rules in use among the resource users, and the public infrastructure providers.

The interactions of the four components lead to outcomes. We are especially interested in how the interaction between resource users and public infrastructure providers leads to infrastructure that facilitates productive outcomes. We are also especially interested in the robustness of the coupled infrastructure system, which is the focus of the next section.

Inequality is an important component of the functioning of coupled infrastructure systems. We know from historical research and experimental studies that inequality may have negative consequences for the ability of groups and societies to solve collective action problems. For example, where do we place the nuclear power station, or which economic sectors will have to reduce their water use to avoid the major consequences of a drought? If we have to reduce our carbon footprint will the average Joe have to forgo their holidays (carbon emissions from travel) while rich households can buy additional carbon emission rights? What happens if rich neighborhoods get off the grid by powering their houses with solar energy and driving around in Teslas? Those who do not go off the grid will now have less capacity to maintain an already ageing infrastructure.

What if an elite group in society is better represented in the category of public infrastructure providers compared to a lower income group? How will this affect the kind of policies that are developed, what types of public infrastructure are produced (i.e., defense versus health care and education or environmental protection) and how the fairness of those infrastructures are perceived?

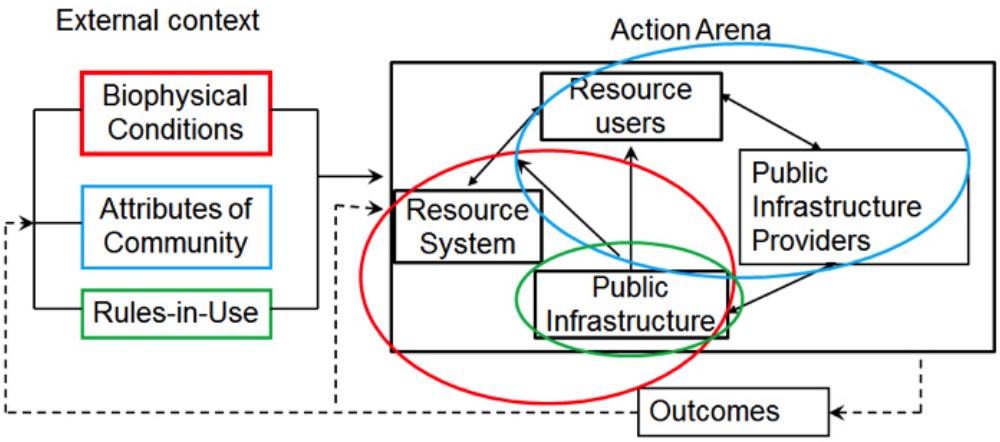

Figure 13.2: The coupled infrastructure system can be seen as a component of the IAD framework. The resource system and the public infrastructure are directly related to the biophysical conditions. The resource users and the public infrastructure providers are directly related to the attributes of the community. And the public infrastructure is directly related to the rules-in-use.

13.5 Robustness of coupled infrastructure systems

Coupled infrastructure systems experience many type of disturbances. For example, weather, insect outbreaks, and earthquakes can impact the shared resource system as well as the hard public

infrastructure. External changes imposed by higher levels of governance can impact the soft public infrastructure, resources users, and public infrastructure providers as well as cause changes in prices of inputs and outputs, infectious diseases and technological innovations. "Robustness" refers to the capacity of a particular coupled infrastructure system to cope with such shocks and continue to deliver benefit streams.

If a coupled infrastructure system is to be robust, a disturbance should not fundamentally disrupt the functionality of the system and the system should regain its basic performance relatively quickly. Earthquakes can cause major damage. In the early months of 2010 there were two major earthquakes. A magnitude 7.0 earthquake destroyed the hard and soft infrastructure of Haiti on January 12, 2010. Years after the earthquake many people still live in camps, some with only basic sanitation. The total death toll is not known but is believed to be beyond 50,000. In constrast, on February 27, 2010, Chile experienced an earthquake with magnitude 8.8, which is much stronger than what Haiti experienced. Yet the total number of fatalities was 497, mainly due to a tsunami caused by the quake. A year after the earthquake, most of the damage, including damage to roads and bridges, was repaired.

What might explain the difference in responses to the earthquakes in the different countries? First, note that Chile has very strict building guidelines to improve the ability of buildings to cope with earthquakes (i.e., to be robust to earthquakes). Since there are so many earthquakes in Chile, one has to build with the right materials and construction design. There is a general awareness across the population about the danger of earthquakes, and individuals, families, and organizations regularly practice what to do when there is a major earthquake, that is, they have invested in knowledge and emergency response protocols to increase robustness (what kind of infrastructure is this?). In the less economically developed Haiti, earthquakes are less frequent than in Chile. Thus, there is much less experience with major earthquake disasters. Because of this lack of experience (an element of human capital) there was no attention or resources allocated to mitigate the effects of potential earthquakes. The weak soft infrastructure hindered the ability of Haiti's government to implement effective disaster risk-reduction measures which reduced the robustness of the hard infrastructure to earthquakes.

Chile has a more robust coupled infrastructure system to cope with earthquakes compared to Haiti. Due to the frequency of earthquakes and the occurrence of the largest magnitude earthquake ever measured (9.5) in 1960, the Chilean government created strict building guidelines to reduce the impact of future earthquakes. Since building robustness has a cost, one has to define priorities to guide how resources are allocated. It is not uncommon that after a major disaster, new regulations are put into place to reduce the impact of rare, major shocks, whether they are earthquakes, floods, or forest fires. Regardless how much and in what capacities governments invest, coupled infrastructure systems cannot be robust to every possible shock. Scholars who study these systems thus speak about systems being "robust yet fragile." A system can be designed to be robust to one type of shock but can, as a consequence, become vulnerable to other types of shocks. The simplest example is the sea wall that protects a community from annual storm surges but makes it more vulnerable to rare surges that happen once a century. At a more basic level, the resources used to build the sea wall cannot be used to invest resources in becoming robust to another type of shock. These examples illustrate that the "robust yet fragile" nature of coupled infrastructure systems play out in multiple ways.

In recent years the U.S. has experienced major damage due to hurricanes such as hurricane Katrina (New Orleans) and hurricane Sandy (New York City). Those hurricanes demonstrated the vulnerabilities of coupled infrastructures, especially due to flooding. Those vulnerabilities were well known in the scientific and engineering communities, but were not considered important enough for

governments to act on. As mentioned before, being robust to specific threats requires priority setting.

With the anticipated climatic change over the next century, we expect more frequent and/or more intense hurricanes. As a result, vulnerable urban areas are now rethinking what it means to be robust. Does this require a different way to produce and distribute clean water, energy, and information? Do we continue to invest in cities which are in vulnerable areas, especially due to the rise in sea level, such as New York City? Would it be best to abandon the types of coastal natural infrastructures that support iconic cities and stage a slow, directed resettlement? How many resources should be spent by all tax payers to protect a small proportion of the population that lives near vulnerable coastal areas? These questions highlight the challenging choices and trade-offs public infrastructure providers must make as they allocate scarce resources to invest in different types of infrastructure that constitute the coupled infrastructure systems upon which we all critically depend for almost all aspects of our welfare.

Figure 13.3: New Orleans after Katrina.

13.6 Critical reflections

Infrastructure may be taken for granted, but it is critical to generate the services and resources we need for our daily lives. There are different ways we can organize the creation and maintenance of infrastructure, and the institutional arrangements (soft infrastructure) that affect the robustness of coupled infrastructure systems.

13.7 Make yourself think

1. Who paid for the creation and maintenance of roads you take to campus?
2. How is the electricity generated that you use at home?

3. Maintenance of roads is paid largely from gasoline tax. What are the consequences of more energy efficient and even electric vehicles for the continued maintenance of the road infrastructure?

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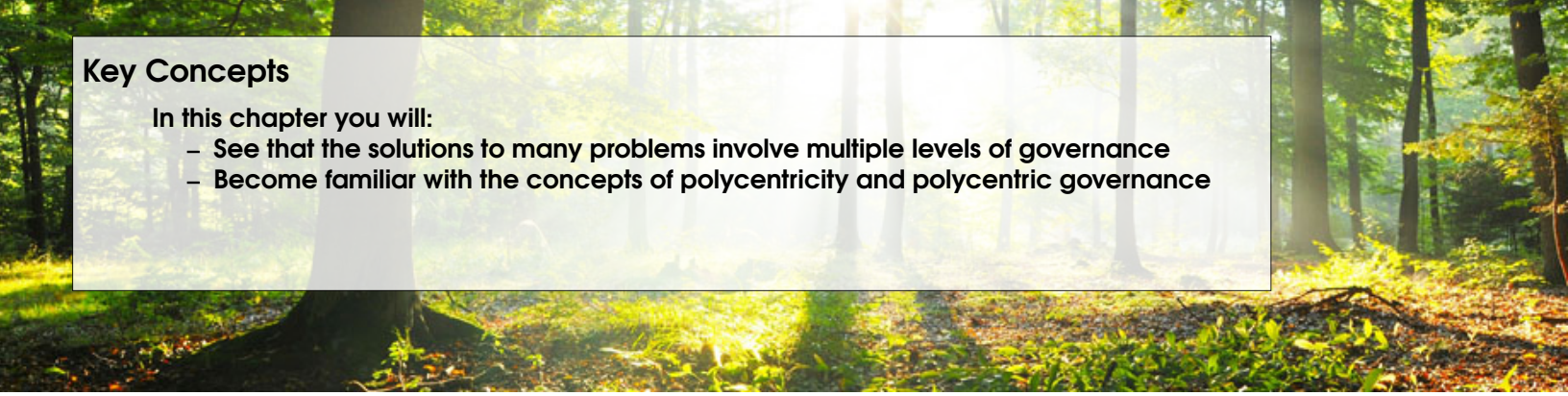

Key Concepts

In this chapter you will:

- **See that the solutions to many problems involve multiple levels of governance**
- **Become familiar with the concepts of polycentricity and polycentric governance**

14 — Think Globally, Act Locally?

Global Treaties Addressing Climate Change

As we write this text, delegates from all over the world are coming together for an important conference on climate change in Paris, France to attempt to reach an agreement on emissions reduction. This will likely be the last chance to sign such an agreement to avoid dangerous climate change. We could have written these same sentences at several points in the previous two decades. Every few years there is a critical conference on climate change, and every time, thus far, the agreements made are limited and do not result in actual changes that bring about emission reductions.

Figure 14.1: International Negotiations.

Climate change is a very challenging problem since we cannot exclude anyone from using the atmosphere to dump their carbon waste (we all do it every time we take a car, bus, or plane ride). Nor can any individual or group really shield themselves from the consequences of climate change. Thus, solutions will require that a large number of people change their behavior at a cost to themselves, for the benefit of everyone—a classic social dilemma. Moreover, the benefits will only be experienced decades later by future generations. If we cannot solve the climate change problem through negotiations at the international level, at which level of organization might we attempt to address the problem?

14.1 Introduction

In this book we have mainly discussed examples of local and regional commons. We have seen that communities can be successful in governing their shared resources. One of the key problems of governance of resources shared in common is the problem of scale. If one looks at resources beyond the community level, the number of actors involved starts to grow substantially in many cases, and many of those actors have overlapping responsibilities and authorities.

For example, the Colorado River passes through five states in the U.S. and two states in Mexico. Actions of the upstream states affect the downstream states. At the time of the writing of this book, the southwestern region of the U.S. had been experiencing a drought for many years and this led to tensions over water availability for the different states. As we discussed in Chapter 5, the U.S. Supreme Court has ruled on the allocation of Colorado River water, but that allocation was based on a period of higher-than-average water supply and much lower population densities. What will happen when Lake Mead dries up and no water is allocated to Arizona? Will upstream states be

requested or required to reduce their water use? Who will enforce this?

The allocation of Colorado River water is a traditional case of the problem of scale. The governance of rivers that cross state and/or national borders can be problematic as a result of the fact that there are many actors from different jurisdictions with different regulations that don't align well trying to work together to solve many problems. For examples, check out the website http://www.internationalwatersgovernance.com. It is not uncommon that organizations are created to focus specifically on the governance problems of a particular river, as happened with the Rhine River in Europe. In the 1980s the downstream country, the Netherlands, experienced major problems with the pollution caused by upstream nations like Germany and France. In order to solve the problem, regulations had to be implemented in different countries. The main costs of the regulations fell to the upstream countries and the main benefits were enjoyed by the downstream countries. Such a policy involving a complete mismatch between costs and benefits of the individual stakeholders could not be implemented unless there is coordination, monitoring, and enforcement at the river basin level.

Other examples of institutional arrangements that cross biophysical boundaries are natural parks and protected areas. Parks that cross nation boundaries may or may not have fences marking the national boundaries. In this case, national boundaries demarcated by the physical infrastructure of a fence create an artificial boundary that can cause various social and ecological challenges. Fences might be created to mitigate the traffic of humans and economic goods, such as at the border between Mexico and the U.S., or at the border of Zimbabwe and South Africa. Border crossing by humans is regulated for various political reasons, for example, to limit the amount of undocumented immigrants. However, a consequence is that many animals also cannot cross the border. But the habitat of these animals may cover the areas across both borders. In such cases, reducing the ability of humans to cross a human-made border may have significant ecological impacts.

Ocean fishers experience almost no physical borders as they fish on the open sea. One of the only "boundaries" is the maritime boundary that extends 200 nautical miles from the coast of each nation as established by the United Nations Convention on the Law of the Sea (UNCLOS). This boundary, however, exists only on paper and is extremely difficult to enforce. The rest of the ocean, the so-called open ocean, is not a territory of any nation, which leaves many ocean fisheries completely open access. It is no surprise that oceans are overexploited. For some species, like whales, agreements have been created where nations can voluntarily commit to not fish whales for commercial purposes. This has limited success because some countries that like to fish for whales do not join such agreements, or, if they do, they often find a loophole. For example, Japan continues to catch whales but argues that this is done for the scientific study of whales.

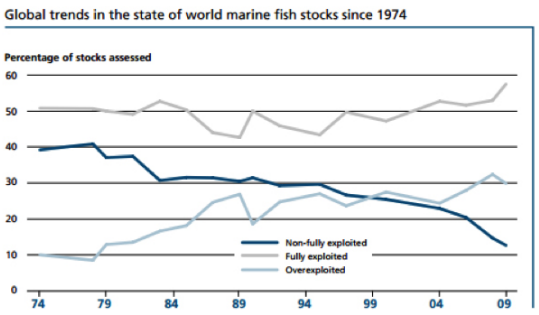

Figure 14.2: Global trends of fish stocks.

14.2 IAD framework and large scale governance

Although mainly developed to study what we might call local systems, such as provision of public services in a city or the maintenance of a small irrigation system, the IAD framework can be used to analyze the governance of larger scale systems. In larger scale systems we may have to

define a number of different action arenas at different scales to analyze the problem. For instance, the Colorado River example has an action arena at the "Basin State" level (a collection in which the participants are states, or more accurately, representatives of states, who may be negotiating water allocations for a particular year consistent with existing laws and regulations). But there are also action arenas at the state level where participants such as residents, governmental officials, water companies and businesses regularly make decisions about the incentives affecting water use. Residents may have voted for officials who, once elected, represent them in local government bodies and who may decide on restrictions for yard vegetation, outside water use, or new taxes for water use. Water companies set the price for their product, comply with local and federal regulations, and have to make decisions on investments to secure water for their clients in the coming years.

14.3 Polycentric governance

As we have seen in previous examples, the governance of shared resources in larger systems can become complicated. A bottom-up approach might be problematic due to a lack of coordination among different actor groups and an inability to constrain actions of particular actors that negatively affect the welfare of others. A top-down approach might solve the coordination and enforcement problem, but as we saw in the previous chapter, may involve a big separation between the resource users and public infrastructure providers, making the transmission of information across levels of organization difficult. As such, top-down approaches may be less effective in monitoring and enforcement and may lack knowledge in creating institutional arrangements that fit the local conditions. A third approach is **polycentric governance**.

Polycentricity refers to a social system composed of many decision centers having power to make decisions. Each decision center has a limited and autonomous set of prerogatives (rights and privileges) over certain sets of potential actions, and operate under an overarching set of rules. The concept was developed in the 1950s and 1960s by scholars focusing on governance of metropolitan areas (i.e., to provide policing, road maintenance, etc.). For a metropolitan area it might be effective to have just one crime lab rather than one in each neighborhood. But for a typical police officer, it is important to have a police station in each neighborhood instead of one centralized police station. For the performance of the police it is important that officers have access to local knowledge and connections with the neighborhoods both of which cannot be achieved if they are housed in one central police station. For different functions there might be infrastructure at different scales, and each function might have its own rules and regulations on how the infrastructure is supported. For example, schools in the U.S. are supported by tax revenue at the school district level, and thus richer neighborhoods often have schools that have better infrastructure. Further, if infrastructure is more desirable in other neighborhoods, we may observe families moving between neighborhoods setting up a vicious cycle. People who can afford it vote with their feet. Those who can't, are stuck. To avoid major inequalities between neighborhoods, tax revenue at the metropolitan level might be distributed to help schools in poor neighborhoods.

The United States of America, for example, is organized as a polycentric system. The 50 states have their own rules and a certain level of autonomy to make specific types of decisions. This can be observed by differences in regulations, from death penalties to recreational marijuana use. For many types of problems, states have authority to implement laws and regulations that are consistent with the attributes of the local population. Certain problems, such as national security, national currency, and trade agreements, cannot be addressed at the state level and this will be addressed at the federal level.

Which level is the proper level of authority is not without controversies. For example, due to the decision of the federal supreme court, same-sex marriage is now allowed in each state. Before the supreme court's decision same-sex marriage was allowed in a select number of states. Some people argue that the meaning of marriage should be regulated at the state level (i.e., is a matter of states rights), and do not agree that a federal mandate should be imposed on a state. On the other hand, before the federal ruling a married couple who moved to another state may have experienced different regulations, which could have had major consequences for that family.

Polycentric governance, also referred to as multi-level governance, has increasingly become an important issue in the sustainability discourse in recent years. For example, within the European Union environmental goals are formulated for Europe, the implementation of which will have to be carried out at the nation-state levels with their differences in norms, preferences, economies and biophysical contexts. Creating habitats for larger predators such as wolfs and bears will require cooperation between countries to create ecological zones where those species can have a supportive habitat. Prevention and containment of infectious diseases among livestock requires an elaborate registration of all livestock such that one can monitor their movement in the market. Furthermore, local actors need to report cases of infectious diseases in a timely manner so that the disease can be contained.

One of the ultimate problems faced by governance bodies is the overuse of the carbon assimilation capacity of the atmosphere and the resulting global climate change. We will discuss this problem in more depth and use the polycentric governance perspective to uncover some possible trajectories for positive change.

14.4 Global climate change

Humans influence the global climate system by emitting large amounts of greenhouse gasses such as carbon dioxide, methane and nitrous oxide. These emissions are a consequence of burning fossil fuels, land use change, and agricultural activities. Since the industrial revolution, the concentrations of greenhouse gases in the atmosphere have been increasing and the expectation is that this trend can lead to an average temperature increase of 2 degrees celsius by the end of this century. There are many uncertainties regarding the specifics of the consequences, and experienced weather changes will likely be quite diverse and vary geographically. To reduce the extent of climate change we need to reduce emissions of greenhouse gases substantially. Since the gases remain in the atmosphere for years it does not matter where emissions have taken place. Therefore, to have a measurable impact, emissions need to be reduced at a global level.

Since the early 1990s, several international negotiations have taken place to develop agreements to reduce emissions. In 1992, the United Nations Framework Convention on Climate Change was created, which had as its aim to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." In 1992, CO2 concentration was 356 ppmv. At the time of the writing of this chapter, the concentration has increased to 399 ppmv. In fact, every few years new treaties are signed with ambitious plans to reduce emissions, but none have had a measurable impact.

Why is the problem of climate change so difficult to solve? Emission reduction at the global level requires that we not use cheap available fossil fuels such as oil, coal, and natural gas but, rather, use alternative energy sources and reduce our overall energy use. This will require major technological innovations and behavior change, which may affect both economic growth and our well-being. Should a country like the U.S. that has historically emitted the most greenhouse gases

make a bigger contribution to the solution compared to other countries? Will we allow countries like India and China to grow their emissions in the coming years since their emissions are low in per capita terms compared to other developed nations and because these countries are relatively less developed? On what ethical basis could we prohibit some Chinese families from enjoying a private car when such is allowed in other countries? Countries like the Maldives will disappear in the coming decades due to the rising sea level and other consequences of climatic change. Who will take care of the climate refugees? What will happen if countries do not do what they promised? Can we enforce the rules?

As you can see there is no simple solution to the greenhouse gas emission problem. Instead of giving up and continuing with business as usual, we can explore the problem from a polycentric perspective. There are many actors around the world who want to make a difference. There are states, cities, universities, and towns that have committed themselves to reducing greenhouse gas emissions. For example C40 (http://www.c40.org/) is a network of megacities who are committed to implementing practical solutions to reduce emissions and create a sustainable future for their citizens. Many of these local actors are driven by the fact that their efforts to reduce emissions also contribute to solving other problems such as local air pollution and the cost of energy use.

Such "climate clubs" have the benefit of starting with actors who are motivated. Participants who want to join opt in and must agree with the rules of the club. Clubs can then set examples of solutions and exchange lessons learned from their local attempts to implement solutions.

The governance of climate change can be addressed using the IAD framework by recognizing that different action arenas take place at different levels. At the global level delegations of governments negotiate to come to agreements on emission reduction allocations. Some countries, who have historically emitted more, are asked to make bigger contributions than developing countries. The rules in use relate to international law, with all its imperfections, to regulate and enforce agreements. As a result, agreements at the international level will be vague and open-ended. At a national scale, representatives of civic society, business, and government negotiate to come to agreements to meet certain emission reduction standards. Decisions at this level will be more concrete and will need to comply with national law. Decisions might include implementing a carbon emission rights market, investments in clean energy, and nudging behavioral changes. In principle, national level governance should have leverage to enforce regulations. In practice, because of the efforts to allow capital to move freely as part of economic globalization, companies may move their operations to countries with weaker regulations. Finally, we may have local level governance by which organizations such as Arizona State University, aim to become carbon neutral by 2035. In this action arena the participants are students, faculty, and staff, along with collaborators from business and governmental agencies. The biophysical context is the campus within a sprawling city in a desert environment which allows for certain types of policies but not others. Although the impact of reducing ASU emissions is modest, it will have more impact since it can set precedence for the students who move beyond ASU and project their ideas as they participate in other levels of organization.

14.5 Critical reflections

In this chapter we have considered the challenges of governing systems at larger scales. Who has the authority and the knowledge to create effective policies? To address global problems requires global level action, but this does not mean that we have to wait for binding agreements between nations. Global level actions could be initiated by many local level initiatives where communities implement policies in their context to meet global ambitions.

14.6 Make yourself think

1. List some examples where poor communication between multiple levels of governance has caused a problem for you, a family member, or a friend.
2. What does the history of climate negotiations suggest about the potential for "earth system governance?" What do you think would be required to make it work?
3. From an institutional (Ostromological) perspective, what are the key imperfections in global governance sytems?

14.7 References

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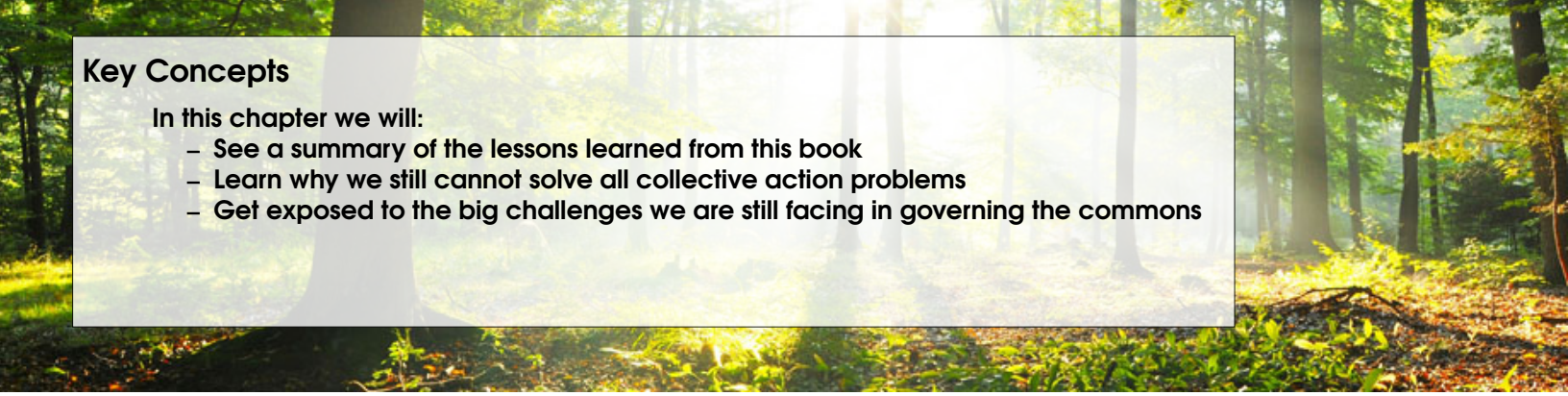

Key Concepts

In this chapter we will:

- **See a summary of the lessons learned from this book**
- **Learn why we still cannot solve all collective action problems**
- **Get exposed to the big challenges we are still facing in governing the commons**

15 — Challenges Ahead

15.1 What have we learned?

This book has provided an introduction to the study of institutions and governance in general and of governance of the commons in particular. Common-pool resources often face the challenge of overharvesting, while public goods face the problem of under-provision. Despite the difficult challenges associated with governing these types of goods, we see successful performance of many common-pool resource systems and successful provision of public goods. We need to extend the lessons learned from these successes to better understand the general properties of different approaches to successfully governing the commons.

Elinor Ostrom developed a coherent theoretical framework that enables scholars to clearly articulate how institutional arrangements can facilitate successful governance of the commons. By institutions we refer to the *prescriptions that humans use to organize all forms of repetitive and structured interactions*. The prescriptions are rules and norms. They apply not only to common-pool resources such as groundwater, but also to other types of social dilemma situations like traffic, Wikipedia, sports, and health care.

Rules can be written laws, or agreed upon and commonly understood verbal rules in a community. Norms do not include explicit consequences if forbidden activities are performed or requirements are not met. Even though not explicit, not following social norms may have negative consequences since people may decide to avoid interacting with people who have bad reputations.

A key concept in studying institutions is the action arena. An action arena consists of people as participants and an action situation in which they participate. When people interact in an action situation, they make decisions based on the choice rules associated with the position they occupy in that action situation. In a given action situation, people may hold different positions and therefore may not be able to make the same decisions, or have the same information. The interactions of the participants lead to outcomes that can be evaluated.

Figure 15.1 shows the schematic representation of the Institutional Analysis and Development (IAD) framework and highlights the key components necessary for studying how institutions structure action situations. The IAD framework emphasizes the fact that action situations are influenced by broader contextual variables. The biophysical conditions—whether you live in a desert or a rainforest—affect rules and norms concerning how to build houses and how to organize health care (e.g., due to different diseases that are prevalent in a given area). The attributes of a community such as the age and income distribution, education, and kin-relationships, affect which kind of interactions one can expect in action situations.

The rules-in-use are one of the key foci of the IAD framework. Rules on paper are important, but if those rules are not known, understood, and accepted by participants in the action situation, they will not effectively guide behavior. In studying the governance of the commons, we are interested in which rules people actually use, how they monitor rule compliance, sanction rule infractions, and how contextual variables impact how the rules function.

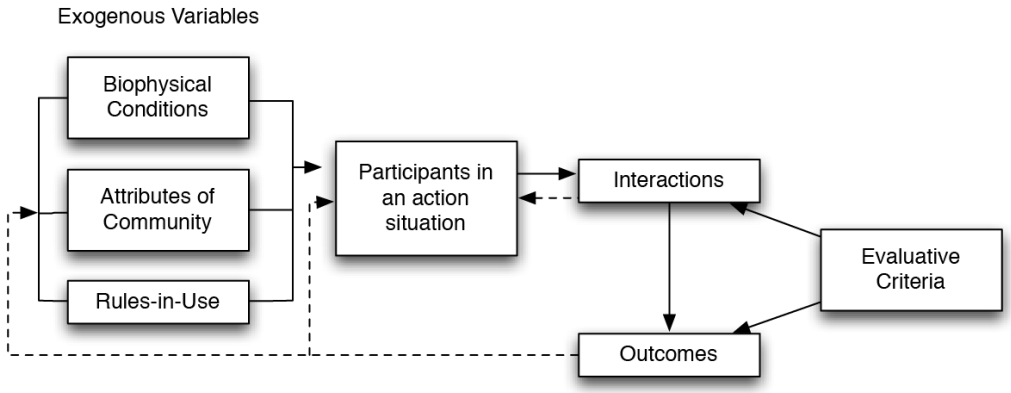

Figure 15.1: A framework for institutional analysis (adapted from Ostrom, 2005).

We have illustrated the application of the framework through several examples. The framework is just that—a framework. Frameworks are an articulation of key elements that should be considered when trying to understand the impact of institutional arrangements on human behavior and social interactions. The framework provides a set of concepts and language that enables scholars to communicate effectively about the key working parts of an action situation. Thus, if a student has developed a working knowledge of the IAD framework, they should be able to translate observations of social phenomena into the language of the IAD Framework and action situations. This process of translating phenomena into a formal language enables us to compare different cases and uncover regularities.

It is important to understand that the IAD framework is not a theory. It does not suggest a hypothesis about how different parts of action situations relate to outcomes. Theory relevant to understanding social phenomena is an additional layer related to how people make decisions in different action situations. We discussed one theory of human decision making called rational choice theory. We then discussed experimental work that shows that this theory of behavior holds only in certain circumstances. Human decisions take more into account than narrow self interest. We illustrated the importance of this fact through experiments of social dilemmas.

Much of the discussion and the majority of examples focused on a particular context that we call the commons. We study the commons because many examples of the most difficult problems we face today are commons that involve social dilemmas. In those situations there are incentives for individuals to free ride on the cooperative actions of others. We experience social dilemmas in many action situations in our daily lives. For example, who is doing all the work in a group project, how do we pay for the highways we use, how do we make sure there is health care available when we need it, who writes the articles on Wikipedia, are our bridges being inspected for safety, who reduces their energy use to help reduce pollution?

How do we organize incentives such that we reduce free riding in problems associated with issues we care about? One option is to use coercion. If people have a tendency to free ride on the

cooperative behavior of others, then privatization of common-pool resources and public goods is an option. The reasoning is that individuals will make better decisions regarding the use of private goods. We illustrated the problems associated with common-pool resources with an example in which multiple people share a meadow. Each individual has an incentive to add animals to the meadow and when everyone in the group does so, this will lead to overgrazing. If, on the other hand, everybody owns their own a part of the meadow, everybody will take care of his own property and won't damage others' property. Another policy might be to tax the use of resources, so that people will not overuse common-pool resources.

Both of these economic instruments (privatization and taxation) are used in managing the commons in practice. However, these instruments face several practical limitations and are not the only options available. There are many examples of self-governance, meaning that the users and producers of the commons are crafting, implementing and maintaining the institutional arrangements themselves. Based on these institutional arrangements, communities can successfully govern the commons without privatization or taxation from an outside governmental body.

The challenge that the tools developed in this book are meant to address is to understand what kind of institutional arrangements are successful in which circumstances. A coercive approach is not necessarily a productive approach. Coercion may demotivate participants. Providing monetary incentives may also not always be beneficial. An illustrative example is a study by Gneezy and Rustichini (2000) on daycare centers. Parents often come late to collect their kids from daycare. To reduce the number of people who are late, an experiment was performed that imposed a monetary penalty when parents were late. Surprisingly, parents came late more often. Why should anyone complain when they have paid for it? Parents who were willing to pay the price could come late without feeling guilty. When the daycare centers wanted to revert back to the original situation and remove the penalty, the number of parents who came late remained high. A behavior that is a moral obligation (coming on time to collect your child) became an economic transaction (paying a fee). This is a risk of using economic incentives to stimulate behavioral change; it may have unintended, difficult-to-reverse consequences.

The study of successful institutional arrangements shows that it is important that participants in action situations are involved in the creation of rules, that there are low-cost conflict-resolution mechanisms, and that there are clear rules about who and when people can use the commons. Effective institutional mechanisms stimulate personal interactions that facilitate trust relationships and allow participants to build reputations. When people on e-Bay provide feedback based on their experience in the transaction they just finished, it contributes to information about the reputation of their economic partners. When people edit the English text of Wikipedia articles, they gain respect and a good reputation in the community that may enable them to occupy a special role in the community. When a tennis player, who just lost a match, shakes the hand of the opponent, it reinforces the respectful relationship they have with each other.

The emerging picture of effective institutional arrangements is that in order to have success, it is important that people can develop trust relationships, gain a reputation, experiment with new arrangements, tolerate mistakes people make, and have commonly understood rules-in-use. Most of these insights have been derived from studies of communities who share common-pool resources. If we know so much about successes, why are there still so many problems?

15.2 Why are there still so many problems in governance?

In this book we have discussed insights relating to the ability of communities to solve collective action problems. If we know so much about what leads to effective institutional arrangements, why are there still so many problems? What prevents us from sustaining the commons?

More than a billion people around the world do not have sanitation or access to clean water. Many species go extinct each year and human activities cause long-term disruption to biogeochemical cycles in nature. Many of us waste hours each week in traffic jams, download illegal music files, and complain about the performance of elected officials.

Knowing what leads to better institutional arrangements will not solve all these problems. What are the main challenges? What are the open questions in our understanding of institutional arrangements that require further research? In the following paragraphs, we attempt to list some of the most important challenges. This list is not exhaustive but, rather, represents only a starting point.

One of the big challenges in our modern society is the scale of the problems we face. We are no longer living in small communities where we know exactly what everybody is doing. We may not even know who our neighbors are. In an increasingly urbanized world, we interact with many people who are strangers to us. Even so, there is still an incredible level of cooperation in most modern economies. A moment's reflection should give the reader a sense of astonishment at the fact that hundreds of millions of people can effectively coordinate their behavior every day. How do we do this? Institutions are a big part of the story. We are able to signal to each other our reputation and trustworthiness because of the uniforms we wear (in the position of police officer, you *must* wear an official uniform), the tattoos we have, the certificates we have earned (positions defined by boundary rules) and the gossip that is spreading about us. It is not uncommon for us to give a stranger our credit card (backed by an enormous stock of institutions and organizations) to make a payment. We are accustomed to conditionally trusting strangers.

Nevertheless, the larger scale of our interaction spheres increases the possibility that we may lack the appropriate information to make good decisions. Think about people accepting the terms of home loans that they could not understand. Think about large institutional investors who purchase investments for which they cannot assess the risks. The financial crisis of 2008 demonstrated just how calamitous and how much suffering such information failures may generate. There is also the possibility of misunderstandings about our intensions, motivations and the meaning of rules. An important condition of well-functioning institutional arrangements is that rules are commonly understood.

Being in larger groups makes it more difficult for individuals to be involved in rule crafting. In the position of a U.S. citizen of eighteen years or older, you may vote but you may also feel that your vote is insignificant. You may not be able to have an impact on the outcomes at the national level, but you still can participate in local governance issues whether this is through an elected office, community service project, or a volunteer activity for your children's school. Individual actions in the community add up. Because the impact of such activities is difficult to measure, the incentives to take them are weak. This is one of the fundamental problems of society—the under-provision of public goods.

Further, larger groups will make it easier to be invisible as a free-rider. You can be one of the many who do not volunteer. Larger groups make it more likely that there are different opinions and more disagreement among the participants. Disagreement makes it easier not to act, even though we know we should.

How can we stimulate cooperation in large populations? Can we apply the insights from this

book to an urbanized and globalized world? New technologies may provide solutions. Many of us have a mobile phone with us; a small computer that can register where we are and can be used to make photos and exchange information with friends in social networks. Can we use these devices to improve the information we have about each other in order to improve trust in relationships and monitor the actions of each other? How we may be able use the crowd to govern the crowd is an important, open question.

Another big challenge is that new problems always emerge. With every new technology there are benefits but there also come new problems. There was no cyber bullying before the Internet. It is more difficult to bully someone in person than virtually. There was no illegal downloading before digital recording. To illegally obtain a music recording 40 years ago, it was necessary to walk into a record store and walk out with a vinyl disc! Again, before the Internet, stealing was a more personal affair—you had to actually see the victim. Now it has become impersonal. New problems also emerge due to new insights from science. Improved technology allows better measurements and enables new discoveries, such as the emergence of the hole in the ozone layer. Our understanding of chlorofluorocarbons enabled us to determine that they were responsible. Reducing chlorofluorocarbons was fairly easy—the problem was clear, measurable, and well understood. The solution was technologically feasible and economical. This is in stark contrast to climate change, which poses a much more difficult collective action problem. If and when we develop global governance arrangements to deal with climate change, what will be the next problem to emerge? Will human society ever have enough time to solve its existing set of social dilemmas before being presented with another new problem? Or, put in another way, will humans ever learn to craft institutions and governance structures fast enough to address new challenges?

History suggests there are some reasons to be hopeful—e.g., the Montreal Protocol, which deals with chlorofluorocarbons—but the challenges are many. Globalization will bring with it global scale problems. These will require global-level solutions. This will require cooperation between people from many different cultures. New mixtures of populations may require generations to develop commonly understood well-functioning regulations, slowing our capacity to respond. Further, because solving social problems is difficult and complex, people tend to stick with institutions that have worked in the past. The No Child Left Behind program is a good example. The tried and true solutions (based on the Protestant work ethic) of trying to create incentives for more discipline and harder work through higher standards and more measurement simply does not work for a public good like education today. Why? The social context is completely different and "education" is complex. In order to learn more material more quickly as No Child Left Behind demands, children need mentoring. In the past when parents had the time to mentor, No Child Left Behind may have been a great success (at least by its own measure of improved standardized test scores). At present, when in many households both parents work and have little time or energy to mentor their children, higher standards and more testing will have little effect. Old solutions do not translate well to new situations and simple panaceas will fail. Rather, we must perform small scale experiments to get experience with new institutional arrangements in new contexts. Because such experiments are costly and require patience, developing effective institutions will require considerable collective will on the part of society.

The third challenge we face is that it is often not in everybody's interest to solve a problem. Different people have different positions and interests. A problem for one participant can be an opportunity for another. Hence not everybody has an incentive to solve a problem. Problems don't exist in a vacuum, there is already a social and ecological context for every problem we face. If the poor and unemployed don't receive health care, it is not a direct benefit for those who have health

care to pay for and share their health care benefits. The status quo, although not perfect, might be beneficial to many participants as compared to an alternative.

Finally, sometimes constitutional choice rules make it difficult to change a regulation. The European Union now consists of more than 25 nations. The EU employs an aggregation rule by which decisions are made by a unanimity vote. In a unanimity vote everybody needs to vote in favor in order for a proposal to be accepted. If the group is relatively small and people are sufficiently aligned in terms of their understanding and preferences, this will work. But in large groups, one individual country can take negotiations hostage to receive benefits for voting in favor of a motion.

15.3 Closing

In closing we can say that there has been significant developments over the past 50 years in our understanding of institutional arrangements and the way they structure social interactions. This book provides ways to study and analyze institutions. After reading this book, we hope you will view the problems we face everyday and the very diverse ways we are solving collective action problems through a new lens and in a different light.

Different disciplines contribute to our understanding of human behavior in the context of complex social and ecological systems. Unfortunately we cannot provide a blueprint for how to solve all the problems we experience. Experimentation at the small scale and finding mechanisms to connect successful solutions to larger scales are key. Although we cannot provide simple solutions to complex problems, we have provided you a powerful set of tools to make more informed decisions and recognize the importance of your own role in society.

15.4 Critical reflections

The rules and norms that govern human interactions can be studied with the framework that is presented in this book. The framework can be applied to many different topics including sustainability, health care, sports, education and the digital commons. Despite our increasing understanding of institutions and lessons regarding the conditions of successful collective action, there are still many failures.

Major challenges exist in governance in modern society since the scale at which we interact with others is much larger than it has ever been in human history. This makes lessons about success from studies of small groups difficult to apply. Furthermore, we experience misunderstandings if we don't speak the same language or live in different social and ecological contexts. Finally, new problems are constantly emerging due to rapid environmental and technological change.

15.5 Make yourself think

1. How can you make a difference in addressing major problems in society?
2. Ask older family members how they made arrangements for going out (in a time before mobile phones and texting). Do you see changes in rules and norms?
3. What do you see as the most challenging topic of governance in the future?

15.6 References

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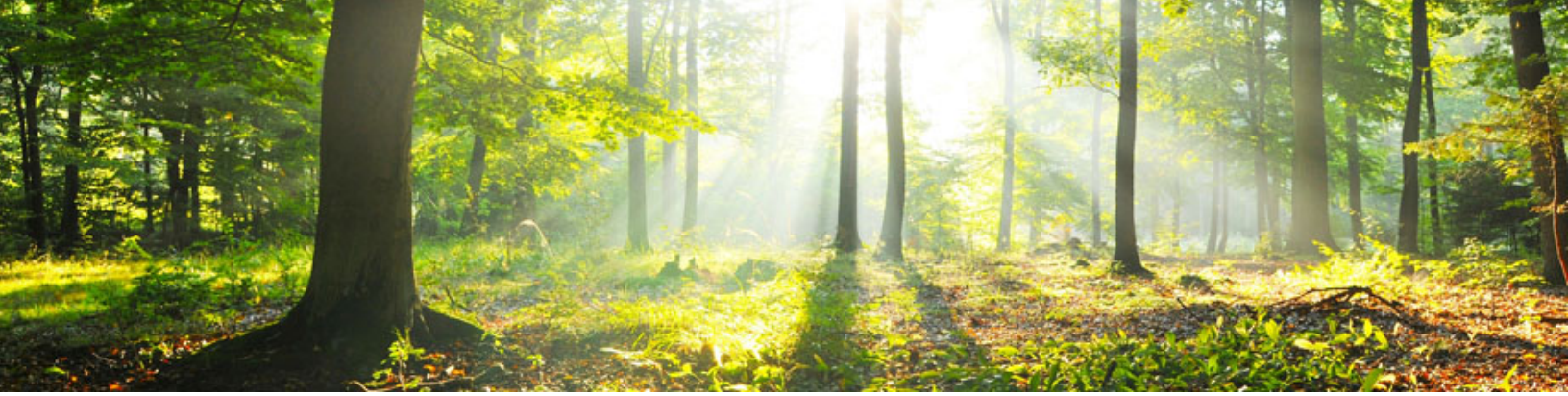

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Chapter 1

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Chapter 2

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Chapter 3

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