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Approaching the Study of Corruption and Natural Resources through Qualitative System Dynamics

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Abstract: The complexity and scale of the challenges posed by the climate crisis demand knowledge sharing and collaboration between a variety of academic disciplines to address them. In that regard, the way in which natural resources are used matters, and more information is needed on which regulatory framework and policy instruments foster their sustainable management. There is consensus that corruption can seriously obstruct social, economic, and political development. However, research on corruption has tended to be fragmented and investigating the concept itself is a challenging endeavor. Due to the complexity of corruption as a research subject, we argue that in seeking to explore and understand corruption, researchers would benefit from using a framework that facilitates an interdisciplinary and process-oriented approach. This paper suggests that the method of system dynamics can be applied to advance the academic discourse on corruption in relation to natural resources, since it seeks to improve understanding and learning in complex systems in an illustrative manner. More specifically, it offers a platform to explore feedback processes between the different social, economic, and ecological dimensions which ultimately produce undesirable behavior or patterns. The paper outlines how corruption has been approached previously in the academic discourse. It then offers a tool to bridge knowledge from different fields on natural resources, in a way that allows for research from different fields to be integrated, and thus gaps are better identified. A process-oriented approach to exploring corruption in natural resource systems based on qualitative system dynamics methods can inform new questions and thus improve understanding about the conditions under which corruption occurs or corrupt behavior thrives.

Keywords: corruption; system dynamics; interdisciplinarity; collective action problem

Citation: Gisladottir, J.; Sigurgeirsdottir, S.; Stjernquist, I.; Ragnarsdottir, K.V. Approaching the Study of Corruption and Natural Resources through Qualitative System Dynamics. *Resources* **2022**, *11*, 69. https://doi.org/10.3390/resources11080069

Academic Editors: Eleftherios I. Thalassinos, Kesra Nermend and Anna Borawska

Received: 30 April 2022
Accepted: 15 July 2022
Published: 28 July 2022

1. Introduction

Research into the topic of corruption took off in the late 20th century due to a growing public concern of the issue [1] and following seminal work such as Rose-Ackerman [2] and Klitgaard [3]. The Transparency International (TI) was then founded in 1993, a non-governmental organization that aimed at raising awareness on the topic, and published the Corruption Perceptions Index (CPI) in 1995, ranking countries based on the public's perceived level of corruption in the public sector [4]. Data is collected through surveys where each respondent answers standardized questions.

Like most phenomenon studied within the social sciences, corruption is a highly contested and debated concept. During negotiations for the United Nations Convention Against Corruption in 2002, corruption was not defined, even after much discussion. Instead, repeated examples of what was covered by the expression appeared throughout the text [5]. That alone tells a story about the controversies regarding this phenomenon. However, the most commonly used definition of corruption is the one put forward by TI, as "the abuse of entrusted power for private gain" [6]. Corruption can, however, take different

forms, and it can be perceived differently throughout the world [7]. It varies in terms of forms, functions, and contexts, deeming it highly complex since it can have multiple causes and effects [1]. It is therefore not surprising that a universal definition does not exist. Most studies on corruption focus on the public sector, e.g., Fishman and Golden [8], while definitions of the phenomenon have increasingly come to reflect that it can be sector neutral [9].

According to Jain [10], research on corruption has tended to be fragmented, as researchers have focused on studying the phenomenon of corruption only within their own academic fields with little attention or understanding for work conducted in other disciplines. As researchers venture deeper into specific types of corruption, they often end up concentrating on a specific part of the puzzle, whether it is psychological, economic, political, or sociological. In her review paper on the drivers of corruption, Søreide [7] states that academic disciplines treat corruption differently. Economists tend to focus on the incentives that influence the behavior of individuals, whereas behavioral scientists and psychologists investigate the limits of human rationality. Political scientists typically conceive of corruption as an issue in a broader analysis of governance systems, while anthropologists focus on norms and societal and cultural frameworks rooted in history that individuals use to determine right from wrong. Academics within the legal field then consider what conditions are in place that hold people responsible [7]. It has been argued that studies aimed at understanding and exploring the underlying causes and mechanisms of corruption have been neglected in the past [9].

The complexity involved in identifying the relationships between economic, political, and ecological factors are perhaps best exemplified in the academic debate on the resource curse, which is relevant for the linkages between corruption and natural resources. Kolstad and Wiig [11] define the resource curse as a pattern of underperformance by resource-rich countries, measured in economic and social variables. Scholars such as Mehlum et al. [12] have posed questions on how the diverging impact of natural resources on economic development in different countries can be explained and suggest that the answer lies in institutional differences. Even though the literature on the subject has advanced, Ross [13] points out the difficulties involved in disentangling the relationships between institutional quality and resource wealth, since it is not easily measured and the direction of the relationship can be in both directions. The literature on the topic is diverse and ranges from dealing with the question of whether the resource curse exists or not, which methods are appropriate to measure it, and what mechanisms can explain it [11].

Actions against corruption ultimately depend on how it is understood. Bunge [14] claims that underlying mechanisms need to be unraveled in order to explain empirically gathered data. Additionally, if that mechanism is unknown, it hinders the ability to regulate it. We argue that due to the complex nature of the social processes involved when corruption takes place, the system dynamics methodology can offer tools to explore the topic in an interdisciplinary way. It can help to expose the underlying mechanisms and untangle the complexity involved. It is only with enhanced knowledge that effective policies can be developed to address the problems that result from corruption.

The aim of this paper is to advance our understanding of corruption dynamics in natural resource sectors. We seek to illustrate how the methodology of system dynamics can be useful for that purpose. This paper is organized as follows: In the next section, we explore the main strands of the academic discourse on corruption and their underlying theoretical assumptions. Thereafter, we introduce the system dynamics approach, and then demonstrate the applicability of using one of its qualitative methods, causal loop diagrams, to allow for an interdisciplinary and holistic approach to the subject. An example of the application of the method and discussion follows, along with a conclusion.

The Academic Discourse on Corruption

What all theoretical approaches to corruption have in common is their quest to make sense of the phenomenon through the lens of the reality they identify with. After the CPI

had been released, economists increasingly engaged with the topic of corruption in their research. The contribution from the field has been towards theorizing the incentives involved in engaging in corruption and rationale behind that decision making. The assumptions that are held about what motivates individuals in specific settings and what drives their behavior is highly relevant. It affects the policies chosen to address the behavior deemed to be a problematic one, or policies aimed at incentivizing individuals to do the right thing or perform well.

Thaler [15] predicted that economic studies would increasingly move away from assumptions of the homo economicus, or that individuals can be expected to take rational decisions, to those recognizing the limits of rationality. Herbert Simon's [16,17] influential theory of bounded rationality suggests that humans can not be expected to base their decisions and behavior on what is deemed most rational in every given situation, since the brain does not have the information processing capacity to do so. Other economists, such as Le Grand [18], have covered the motivational aspect behind individual actions and whether people are driven by private interests or the care for others.

According to Søreide [7], microeconomic theories that explain corruption as the result of rational choice are based on the assumption that humans seek to maximize utility and was put forward by Rose-Ackerman [2]. An individual will therefore participate in corruption if the benefits involved are expected to be greater than the costs. The benefits can be in the form of monetary gains or increased power and status for the individual or his family or group. The costs could include bribe payments to keep the act hidden, efforts to hide the crime, perceived risk of getting caught as well as moral costs of violating societal rules and norms, and risk of damaged reputation [7].

Within the economic field, the principal–agent approach to theorize corruption by focusing on the role of incentives and rational choice of individuals has been covered by seminal scholars such as Rose-Ackerman [2], Klitgaard [3], and Lambsdorff [19]. Theories based on the principal–agent framework work under the assumption that the interests of the principals and the agents diverge and that there is an information asymmetry present in that relationship that favors the agent [20]. Traditionally, it has been applied in situations where corruption is seen as the abuse of public office for private gain, deeming the rulers as principals and bureaucrats as the agents. In a democracy, the principal would then be elected by the public and be accountable towards them. The agent, or bureaucrat, carries out tasks assigned to him/her by the principal, who then holds the agent accountable. Agents are assumed to have incentives to use their position to maximize their own welfare or benefits while disregarding that of the principal [21].

The principal–agent approach favors anticorruption policies that tackle the information asymmetry between the principal and the agent through, for example, increasing monitoring mechanisms, enhancing transparency, or strengthening sanctions, so that the incentives of agents and principals come to align with one another [22]. Persson et al. [23,24] claim that the reason anticorruption reforms tend to fail in countries where corruption is systemic is that the problem has been theoretically mischaracterized as a principal–agent problem. They challenge the assumption that there are always principals that care about corruption and are willing to hold officials accountable for engaging in it. If the rulers or principals are themselves corrupt, the framework fails as an analytic tool in explaining corruption [23]. Nevertheless, the principal–agent approach can be well-suited to explain certain types of corruption or in specific contexts, which is among the reasons why this strand in the literature has become one of the dominant ones. Additionally, as Marquette and Peiffer [22] have pointed out, the principals are motivated by interests, not principles, and will therefore have an interest in playing their role if they have a stake in the outcome.

The strand that frames corruption as a collective action problem stems from rational choice theory, as does the principal–agent framework, in that it assumes individuals weigh costs and benefits when it comes to decision making [24]. Influential work on collective action theory has for example been that of Hardin [25] and Ostrom [26], which suggests

that when individuals take decisions based on their own short-term benefits, it can end up compromising long-term benefits for the whole.

Scholars such as Bauhr [27], Mungiu-Pippidi [28,29], Persson et al. [24], and Rothstein [30,31] characterize corruption as a collective action problem. The main content of the theory revolves around the perceptions we hold of others, and people's expectations are shaped by what they have come to expect of others. That means that an individual engages in corruption if that is what he/she has come to expect of others and has therefore little incentive to refrain from it. However, expectations of consequences for your actions also come into play [29]. This framework describes corruption as a vicious cycle that is hard to break out of. What actions you decide to take in each situation relies on what actions you expect of others and can therefore be termed as rational behavior for an individual, even though it leads to collective irrationality [31]. Capacity for collective action is seen as a public good that can, among other things, control extreme individualism and is brought about by extensive interactions within society [29]. The concept of impartiality in the way public power is exercised or implemented is central to the idea of quality of government, which is seen as the opposite of corruption [30].

Critics of this theoretical characterization of corruption claim that it asserts a particular normative view on the role of the state, and when deviations are detected from that normative philosophy, it is deemed as being corrupt [32]. However, Rothstein [30] claims that as corruption is often defined as the misuse or abuse of public power for private gain, it is not possible to determine what that abuse or misuse constitutes without having a normative standard of what the role of the state should be.

Scholars including Marquette and Peiffer [22,33] have claimed that the two frameworks that are at the forefront of the theoretical corruption discourse, namely describing it as a principal–agent problem or a collective action problem, are not necessarily contradictory but complementary. That is because both theories operate under the assumption that individuals are rational in their decision making and weigh the pros and cons involved with engaging in a corrupt act before they take a decision. It has been recognized that the complementary nature could apply in cases of nonsystemic corruption [24]. Furthermore, Marquette and Peiffer [22] state that corruption exists to serve as functions for providing solutions to everyday struggles in people's lives, and that effective anticorruption policies need insights from that perspective as well as that stemming from principal–agent theory and collective action theory.

The aforementioned approaches can be labelled as positivist, while the postpositivist approach to corruption, which includes scholars such as Johnston [34], accepts that theories, knowledge, background, and the values held by the researcher can influence what is observed. The approach considers corruption to be a socially constructed phenomenon which represents social mechanisms between and within groups [35]. Postpositivistic theories are not after one single truth or out to find the "right" definition of corruption, but rather argue that there are many different varying types of corruption. According to Johnston [34] (p. 6), "corruption implies deterioration or impropriety as judged by some set of standards" and is therefore a normative idea. The relevant questions to ask are therefore where these standards come from and who has an interest in them being upheld.

The postpositivist approach focuses on questions such as who is allowed to decide what the concept on corruption means and how widely those decisions are accepted. Both language and cultural bias are important when coming up with a definition, for example, whether the perspective is too "western". Scholars who adhere to this approach have, for example, criticized the definition of corruption by Transparency International. The discourse is of great importance as well, which relates to the use of language and the meaning we put into words that are being used to describe this phenomenon, as it gives it a value [36]. This approach does not emphasize the individual but rather the social mechanisms involved, and it deals with questions relating to the epistemological foundation of knowledge, about who is allowed to decide what corruption is, and how and by whom it is observed.

In his review paper on the topic of corruption, Jain [10] emphasizes the need for studying corruption as an interdisciplinary phenomenon. In an episode in Kickback—The Global Anticorruption podcast—Paul Heywood identified that even though there have been advancements in the corruption literature in the last decades, there are still gaps in knowledge to be filled. Bringing about a common understanding of what corruption is, what causes it, how much is there and what its impact is remains relevant work. As academics, politicians, and practitioners are all working according to their own agenda, incentives, and constraints, it becomes even more challenging to bridge different perspectives surrounding the phenomenon [37]. Heywood has also called for research into corruption to be applied in specific contexts, for example sectors, rather than focusing on research on the nation–state level. It is highly valuable to gain an understanding of what motivates actors that engage in corruption, what their strategies are, and how they experience corruption [38].

2. Methods and Modelling Corruption

We suggest that there is value in applying a process-oriented approach to study corruption in relation to natural resources, but this is not new in the literature. The economic literature is rich in studies and hypotheses on the subject of corruption [39–41]. Scarcity is an important concept in economics, and Rose-Ackerman and Palifka [42] claim that incentives for individuals to engage in corruption exist because public officials have the power to allocate scarce resources and impose costs. Insights from microeconomics can therefore be useful in structuring efforts to combat corruption. There are a number of academic papers that have made advancements to theorizing corruption with the aid of dynamic models. Andvig and Moene [43] put forth the hypothesis that the level of corruption can vary even in cases with the same socioeconomic structure. They focus their attention on the supply and demand side of economically motivated corruption among bureaucrats and explore the dynamic mechanisms involved with the aid of models with multiple equilibria. Their findings suggest that corruption could be decreased with a wage increase for public officials [43]. Tirole [44] studied individual and collective reputations through a dynamic model and applied it to the phenomenon of corruption, using it to explain why corruption tends to persists over time. He concluded that new group members inherit to some extent the reputation of previous members, which can leave the group in a steady state of bad reputation, as it is a "low-yield individual investment" to demonstrate good behavior.

There are a number of studies that have modelled the resource curse. Torvik [45] claimed that an increase in the amount of natural resources could lead to a decrease in both total income and welfare through a mechanism of rent-seeking combined with increasing returns to scale. Mehlum et al. [12] developed a dynamic model to test their own hypothesis on the concept and determined that the level of institutional quality determined whether countries benefitted from their resource wealth or not, which applied especially in cases of mineral resources. A game-theoretic model developed by Bhattacharyya and Hodler [46] indicated that in cases where there was relatively poor quality of democratic institutions, resource rents led to increased corruption. However, Brunnschweiler and Bulte [47] have criticized studies on the resource curse for defining resource abundance as a ratio of resource exports to GDP, and that it should be measured in terms of the stock of the resource, rather than the economic flows derived from it. Earlier studies on the topic looked at a broad range of resources, while recent studies have tended to focus on mineral and petroleum resources [13]. Results from studies indicate that countries that are rich in such resources are more prone to experiencing the resource curse. Research into other types of resources are scarce, and those that have been conducted suggest that wealth in other resources does not translate into a resource curse to the same extent [48]. Studies such as those of Yilanci et al. [49], which have distinguished data based on the type of the resource and use the Human Development Index to search for evidence of the resource curse, find mixed results. They suggest that while their study provided scarce evidence for validating

the resource curse hypothesis, the complexities involved with the phenomenon might be untangled to some extent by separating the analysis based on the resource type.

According to Ross [13], there are still unresolved issues within the academic debate on the resource curse, for example regarding its scope, the conditions needed for it to occur, and which mechanisms could explain it. He stated that even though different conditions, processes, and mechanisms had been identified through research, more studies were needed to distinguish between them, which remains empirically challenging. Mehlum et al. [12] have also brought up the issue of reverse causalities and omitted variables when studying the resource curse and called for future research to unravel the causal relationships between resource wealth and institutional quality.

We argue that system dynamics offer methods, both in ways of thinking and communicating complex social phenomenon, to advance research where knowledge and input is needed from both natural and social sciences, which applies to the study of corruption in relation to natural resources. By use of the tools available within the field, assumptions about causalities, dynamics, feedback, and behavior can be explored and relationships untangled.

2.1. The System Dynamics Approach

System dynamics comes from within the greater field of systems thinking, where it can be described as one of the methods available for analysis. Not all concepts from systems thinking are considered important within system dynamics or are shared between the two. However, system dynamics does have a great deal in common with the ontology foundations of systems thinking [50]. In essence, it is a method that seeks to enhance understanding and learning in complex systems, and it typically uses a computer simulation model to aid the study on dynamic complexity. The method is an interdisciplinary tool grounded in the theory of nonlinear dynamics as well as feedback control, and both of these approaches have been developed in physics, mathematics, and engineering [51]. System dynamics has for the most part been isolated from the social sciences and the theoretical discussions taking place within that field. As a result, social scientists tend to perceive system dynamics as some form of computer simulation exercise that belongs to the engineering discipline [52]. Forrester [53] claimed that our social systems could be categorized as multiloop nonlinear feedback systems and that the feedback system behavior can be applied to the social system just as it can be to a physical system. System dynamics is suited for studying complex systems, no matter in which field the systems are situated.

Theories are used to guide and aid us in making sense of the world and in our attempt to explain it. Empirical research can be guided by theory or help to theorize. However, all theories on complex social phenomenon eventually have to come to terms with a certain degree of reductionism. Some issues always have to be left out that are deemed inferior to explain the observed reality. Traditionally, finding cause-and-effect relationships has been deeply imbedded in science and is according to Fischer and Riechers [54] a critical part of systems thinking. Systems thinking can be described as an ontology, as it is a certain way to look at and describe the world in front of us [50]. According to Meadows [55], systems thinking is a view or a lens that provides us with the abilities to look at whole systems, understand their parts, and see their interconnections. A system is not to be seen as simply a collection of things, but rather as sets of things that are interconnected in a way that produces behavior patterns that individuals can observe [55]. The systemist believes that complex social systems can only be fully understood by examining how parts of the system interact and are interconnected, but not solely by studying the parts themselves [50]. It is an endogenous view, telling us that things do not just happen for no reason, but that how the system is structured ultimately determines the behavior generated.

Individuals use models every day to enable decision making in both their private lives and in their business lives. Discussions on using models to represent social systems are not in any way new [53]. Models do not have to be quantitative and simulation based, but they can also represent the mental image we carry in our minds of the world [56]. The human brain uses only a part of the relationships and concepts it is presented with since it has

limits to its capacity. That is why researchers claim that our individual mental models are both incomplete and imprecise [53].

Causal Loop Diagrams

Applying a systems perspective can help to clarify the boundary around the reality one wishes to communicate as well as the structure, the feedback, and the mechanism. The approach allows for the use of causal loop diagrams (CLDs), used in system dynamics in order to capture mental models, and can be used as tools for communicating the feedback structure believed to be responsible for a given behavior [51]. The method was also used and developed by Senge [57] in organizational learning and referred to as systems thinking [58]. Systems thinking is helpful when exploring the dynamic behavior of the system and is in its essence a method for qualitative mapping.

Causal loop diagrams are a form of a diagramming language where variables are listed up based on their possible causal relationships. The variables are connected by arrows that indicate the direction of the causal relation of influence [59]. The arrow is assigned a negative polarity if a change in one variable leads to a change in the opposite direction in the other. If the change is in the same direction, positive polarity is assigned to the arrow. The hypothesized relationships imply a causal relation, not a correlation.

The connections between the variables can then form so-called feedback loops. The dynamics come from the interaction of two types of feedback loops in the system, which can either be reinforcing or balancing. The reinforcing loops amplify behavior through a self-reinforcing process, while the balancing ones counteract it with a self-correcting process. Feedback loops can be described as vicious and virtuous cycles, terms that are better known in social sciences.

An example of a causal loop diagram is provided in Figure 1, which contains the abstract variables of X, Y, and Z.

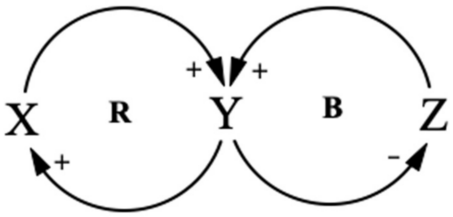

Figure 1. A causal loop diagram with one reinforcing feedback loop (R) and one balancing feedback loop (B).

Here, it is hypothesized that an increase in X will lead to an increase in Y, which comes back to increase X. To determine the nature of the feedback loop, the number of polarities are counted. This loop is a reinforcing one, and therefore labelled with an R since it only contains positive polarities. If a loop contains an even number of negative polarities or minus signs, it is also considered to be reinforcing.

The variable Y is then hypothesized to cause a change in the opposite direction of variable Z, and therefore assigned a negative polarity, as an increase in Y causes a decrease in Z. However, the relationship going from Z and Y has a positive polarity, meaning that a decrease in Z causes a decrease in Y. When negative polarities are counted in this loop, they are an odd number, meaning that the loop is balancing, and therefore labelled with a B. In this case, the balancing feedback loop between variables Y and Z would counteract the reinforcing feedback loop between X and Y.

Feedback loops can expose possible mechanisms [14]. Scholars within the field of system dynamics work under the assumption that the behavior of the system can be determined by its structure and interactions between the feedback loops [51]. Dynamic models must be built with a dynamic phenomenon in mind, where the aim of the model is to achieve an understanding of an observed causal process [60], and mapping up the causal loop diagram can serve as a foundation for the model-building process. The use of this

qualitative mapping approach can generate " . . . *practical knowledge about structural properties as well as presumed actor's behavior can be explicated and made subject of 'theorizing*" [50]. The first step in the process is to elucidate knowledge by using qualitative mapping, and in the second step we come to critical reflection on the diagram generated in the first step [50]. When deemed useful, a computer-simulated model can then be constructed of the system under study to aid analysis. The information gathered in this process could potentially enhance our understanding of the complex system under study through discussions on the underlying assumptions and worldviews that are held by individuals. In fact, everyone is presumed to have a different mental model than the next one and thus interprets the phenomenon under discussion differently [53]. When issues are discussed, each participant in the conversation has his own interpretation and mental model of the subjects, but as we state our assumptions explicitly in a model, we have the opportunity to reveal our mental models and discuss how they compare with others [53]. By using qualitative mapping such as causal loop diagrams, fundamental assumptions are brought to light, which have the potential to open a platform for a rich discussion.

We argue that mapping up the dynamics of corruption in a specific context, according to their causal links into causal loop diagrams, is helpful for scholars and practitioners when communicating their mental models and the underlying assumptions that accompany them. As mental models are exposed this way, it becomes easier for others to challenge the work or add to it. It also aids in identifying gaps in knowledge and adds clarification surrounding the question of what we know versus what is still left unknown. When knowledge is elicited this way, through visual and qualitative mapping to bring structure to thoughts, verbs, and descriptions, it gives a narrative to a certain view of the complex system and the reality believed to exist [50]. Reichel [50] proclaims that as this practice is combined with critical reflection on the structure and narrative created, it becomes easier for others to understand the mental models. System dynamics can therefore enable scientists from different fields to engage in discussions through a common structural language. The words and sentences used to describe social phenomena or to discuss social systems can be limited since language can support multiple meaning, allowing for ambiguity [51]. Diagrams or images are well-suited to serve as a structural language, and that is where CLDs are-well suited to the task of exploring systems. Computer models based on CLDs can then allow for analyzing behavior over time, forecasting, and conducting policy analyses. This formal way of elucidating feedback causality thinking can accommodate well within social sciences and make a contribution to the field [52].

The causal loop diagramming method can therefore add clarity to our thoughts as we organize them into an illustrative form and help us communicate them to others, as well as give us opportunity to challenge them, discuss, and debate. It is also well-suited to facilitate interdisciplinary research, which is highly needed to understand the dynamics of corruption in natural resource sectors, and based on these, elaborate adequate tools to combat it. Even though the CLD method is not without flaws, such as the challenge of representing rate-to-level links [59] or the potential for their use to foster event-oriented or static thinking [61], it is a powerful tool to communicate and discuss feedback structure. Its use can facilitate cooperation and knowledge sharing between social and natural sciences on complex issues that require input from different research disciplines to design appropriate rules and policy instruments.

3. Results and Application

As corruption can have multiple causes and effects, we need context-specific knowledge to determine the dynamics of corruption risks in natural resource sectors in order to generate insights that are of relevance to policy makers. To determine the interrelations between the ecological, economic, and social variables involved, input from scientists from different academic fields is valuable. System dynamics offers a structural language to facilitate interdisciplinary research and collaborative efforts to study the feedback processes driving unwanted behavior.

We suggest that qualitative work is needed to complement quantitative work that explores causal relations between different variables. Both to gain insights into how individuals form perceptions of the resources and behavior of others, and how those perceptions influence decision making within a natural resource sector. Such qualitative research can help to untangle the complexity involved and expose feedback processes that determine underlying mechanisms.

In our research [62,63], we relied on semistructured interviews with open-ended questions posed to stakeholders along different resource value chains to gain insights into the mental models of actors and how that affects decision making around resource management. The first step was to construct stakeholder maps based on the combination of a mind mapping and a value chain approach [64]. That method facilitated gaining an insight into the resource management systems. It also ensured that stakeholders representing different stages along the value chain were included in the research, as well as those considered as value-chain enablers. Key informants were then recruited from various positions on the stakeholder maps, and they both gave an interview and proposed further interviewees, meaning participants were recruited based on snowball sampling [65].

The interviews were coded into causal loop diagrams based on a method developed by Turner, Kim, and Andersen [66,67]. All causal relationships identified by the interviewees are listed up and analyzed while allowing for traceability between the interview text and the causal links, which are eventually represented in the causal loop diagram.

By relying on individual semistructured interviews, the intention was to gain in-depth knowledge of various aspects and perceptions regarding the resource sectors. The causal loop diagrams were therefore meant to represent an interpretation of a collective perception surrounding decision making in the sectors. An important step was then to obtain feedback from key informants on the causal loop diagrams generated through the data analysis phase.

The causal loop diagrams then allow for bridging knowledge between scholars in natural and social sciences in an attempt to gain understanding of the complex decision-making processes involved in managing natural resources. This applies in particular when scholars from different fields collaborate during the phase of data analysis.

To demonstrate the value of the causal loop diagramming method to the study on corruption in natural resource sectors, we provide an example by applying the method to the question of what the dynamics are between corruption in public administration and forestry management. We draw from our previous research on Romanian forestry management in this example [62,63].

In Figure 2, we have drawn up a CLD representing what we have identified as an underlying mechanism of corruption when viewed as a collective action problem.

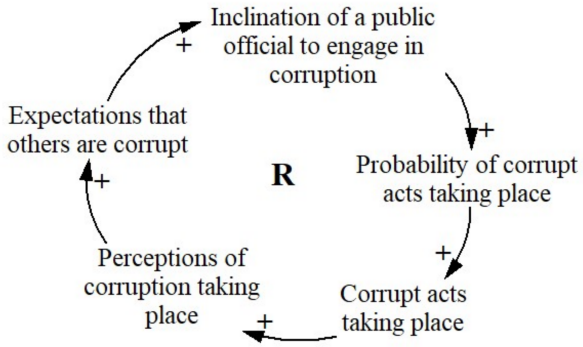

Figure 2. A CLD representing an underlying mechanism of corruption as a collective action problem.

When reading a diagram, the first step is to start with a variable and then trace through the loop. In this case, the higher the inclination of a public official to engage in corruption, the more probability there is of corrupt acts to take place. As the probability increases, so

do corrupt acts. Along with a growth in corrupt acts taking place, so do perceptions of corruption taking place. As corruption perceptions increase, people then have a greater expectation of others being corrupt, which again comes back to close the loop and amplify or reinforce the inclination of a public official to engage in corruption. The identified feedback loop, or mechanism, is then up for debate and discussion, as iterative and critical reflection on the diagram is built into the research process. Do we consider it realistic that this feedback loop exists? Then what are the underlying assumptions we are making? Is the use of language appropriate or are any alterations of terms or words necessary?

To demonstrate that CLDs can be used to explore and communicate causal mechanisms and phenomena, we also provide an example of how the principal agent approach to corruption could be represented in Figure 3.

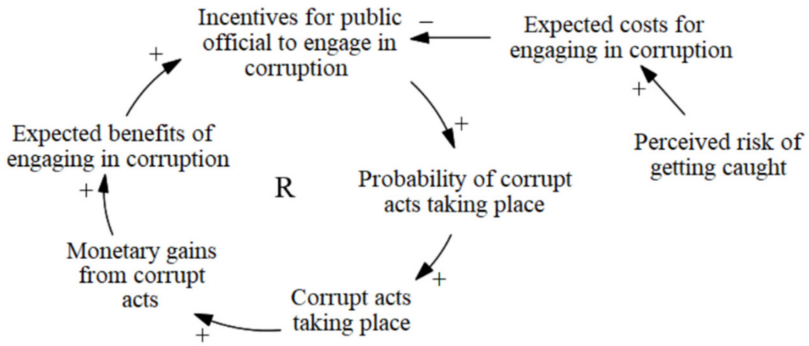

Figure 3. A CLD representing an underlying mechanism of corruption through the principal agent approach.

According to the principal agent approach, incentives of the agent, or in this case the public official, are central to the theoretical argument. Figure 3 represents this as incentives for public officials to engage in corruption increase, and so does the probability of corrupt acts taking place. With higher probability comes an increase in corrupt acts taking place, which brings added monetary gains from corrupt acts, which come back to increase incentives for public officials to engage in corruption. This is a reinforcing loop labelled with R. On the other hand, expected costs for engaging in corruption can have deterring effects on the incentives of public officials to engage in corruption. The expected costs increase if the perceived risk of getting caught is higher. The principal and his/her actions can influence risk perception of the agent, for example if the principal also engages in corrupt acts himself/herself.

When a structure has been agreed upon, the next step would be to add other components to the diagram that are within the boundary of the model, or endogenous. That is, if we believe that additional structure is needed to shed light on the research question.

As we have chosen to apply it in the context of a forestry sector, and therefore build a model to explore the research question, more structure is added to the causal loops. In Figure 4, we have taken the example of illegal harvesting of forests, drawing from our previous research [62,63], and constructed a CLD representing how the underlying mechanism of corruption as a collective action problem can be used to explore corruption risks in forestry.

We took the reinforcing feedback loop R from the previous figure and applied it to a forestry context, where corrupt acts within forestry administration takes place through the vicious reinforcing loop R. As more corrupt acts occur within forestry administration, it results in a higher probability of illegal harvesting taking place. Depending on the rules and regulations that apply, the corruption at the hands of the public official that could result in increased illegal harvesting could, for example, be forging documents, collusion with forest owners to harvest more wood than legally allowed for personal enrichment or inaction when suspected cases of illegal harvesting are reported.

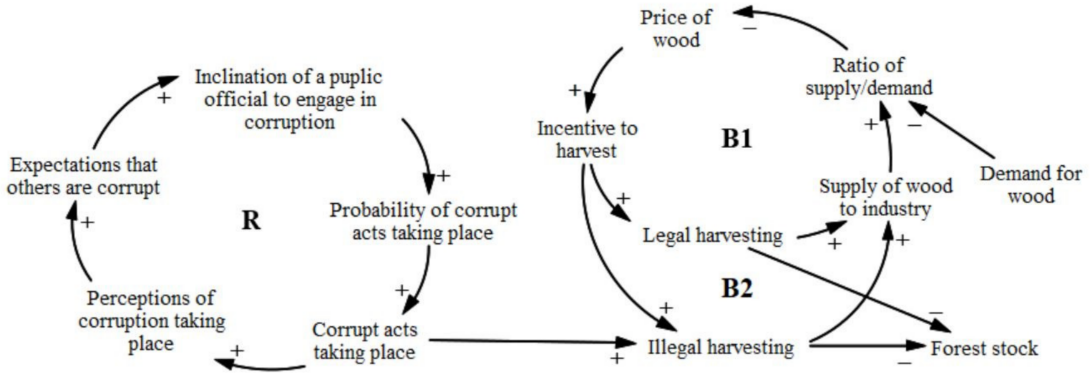

Figure 4. A CLD representing corruption dynamics in forestry.

The balancing loops B1 and B2 then represent the interplay between the ecological and economic dimension. We start by exploring loop B1, but the incentive to harvest the forest grows with increasing prices, which means that more trees will be harvested legally. The supply of wood to the industry therefore grows, and if demand stays constant while supply grows, prices of wood decrease. If demand grows while supply stays constant, prices increase. Balancing loop B2 represents that incentives to harvest forests as a result of rising prices can also lead to increased illegal harvesting of forests, especially in instances where corruption within forestry administration increases. Both legal and illegal harvesting will then decrease the forest stock, or standing trees in the forest, which can mean decreasing ecosystem service provision, and the model could be extended to include such dynamics, if that is not beyond the scope of the research question.

At this stage, critical reflection puts the structure again under scrutiny, as all models represent a limited and simplified knowledge of the real world and the way that the modeler understands it [51]. The iterative process of reflecting on the structure has the potential to bridge the divide between scholars adhering to positivist or postpositivist approaches. The method allows for exploring social mechanism, language, and meaning, while still recognizing causality-based thinking surrounding the phenomenon. Here, questions can be asked in terms of whether the theory of approaching corruption as a collective action problem captures the underlying dynamics in the system under study and can shed light on the incentive of public officials to engage in corruption in a forestry sector.

This approach makes it tempting to add more and more structure to the diagrams as the phenomenon is explored further and in more detail. The analytic challenge is then to figure out what the main structure is, what is most important, and thus simplify the diagram to the extent that it is easily communicated to a wider audience. Simplifying while still appreciating the complexity of the phenomenon is the academic exercise involved in advancing a theoretical discussion. The advantage of this approach lies in the fact that scholars must engage in a process of determining what should be included or excluded in the analysis and why. The process exposes the assumptions made while developing the argument and raises the awareness and transparency of the type of reasoning applied in advancing theoretical arguments. This method allows for identifying gaps in knowledge and where further research efforts should be directed.

When a final draft of the structure is clear, we recommend that researchers validate it by seeking input from interviewees. Should the CLDs be constructed based on data collected through a method known as group model building, where input is sought out from stakeholders in a group setting [68], the structure can be verified through a follow-up session. Once a final structure has been settled on that best reflects the system at hand and captures its underlying mechanism and the dynamic interactions between them, it is possible to move onto the stage of quantitative modelling. This consists of constructing a computer-based simulation model. It depends on the purpose of the study, but quantitative system dynamics models offer the possibility of running simulations to test

different assumptions about future developments. Conducting this research would also provide the ability to engage with the economic literature on dynamic mechanisms related to corruption.

4. Discussion

Scholars such as Wolstenholme [58] recognize that quantifying models can add value and recommend combining qualitative and quantitative modelling. Even though that stage is beyond the scope of this paper, the quantitative modelling stage can further aid to expose areas where additional data is needed and future research should be directed. Quantitative system dynamics models that have been parameterized and can therefore be simulated, offer valuable insights into strength of feedback loops, and therefore guide policy analysis, as simulations offer ways to explore effects of different policy interventions to alleviate the problem.

There are limitations to the process-oriented approach we introduced in this paper. It can be time consuming as it requires interdisciplinary collaboration and requires basic knowledge of the method. Thinking in terms of systems, structure, and feedbacks is not necessarily something that comes naturally, and the language used in this approach might feel alien or overly technical to those with a background in the social sciences. However, it is a way of thinking and approaching problems that allows for exposing the underlying assumption practitioners and researchers have and can reconcile meaning. What is it exactly that we mean by using this term or this phrase when attempting to interpret something? One of the things that are tricky when it comes to social systems, where corruption is no exception, is the use of language. As Sterman [51] points out, as language can support multiple meanings, one must be aware of the ambiguity that can rise. The benefits of using models to represent and study social systems is that they tend to be clear and opt for a simple language syntax. Relationships and concepts that can be described and discussed can also be represented in a computer language.

Recognizing that there is a structure to be identified and analyzed implies a positivist perspective, but a postpositivist approach would regard the "system" to be a subjective construction. Therefore, when studying corruption in a specific sector and setting with an interdisciplinary group of individuals, it can be helpful to discuss such ontological stances and establish a boundary around the system under study to begin with. Reconciling what the system is, how it should be defined, and what is its context or environment, as well as the main components, will aid to establish the boundary and is determined and guided by the research question. We agree with the argument put forth by Forrester [53]: just going through the process of taking the mental model out of your mind and putting it down on a piece of paper, or into a computer model, in itself is highly valuable and offers avenues for rich dialogue to take place. We found this especially to be the case, as the power of the method lies in its illustrative features, which allow for a structural language that can bridge different academic fields to advance knowledge on complex social phenomena in natural resource sectors. Studying phenomenon such as corruption in natural resource sectors will benefit from academic collaboration and an interdisciplinary approach in order to capture the dynamics involved and identify possible leverage points for improvement.

5. Conclusions

System dynamics offers powerful tools to communicate ideas of feedback-driven behavior, through which hypotheses and assumptions surrounding human behavior and resource use can be explored. As such, it provides tools to locate leverage points, and in this case on leverage points to decrease corruption. When theories that seek to explain complex social phenomenon are explored by using tools from qualitative system dynamics, it allows for identifying feedbacks in the system, thereby unravelling the dynamics that are hypothesized to take place within it. More specifically, causal loop diagramming offers a platform for engaging in a constructive dialogue on the underlying assumptions and mental models that each individual brings into the discussion. Even if the individuals have

different views, opinions or theoretical stances, the illustrative features involved in this method, as well as the process of iterative critical reflection it brings, mean that it offers rich avenues for interdisciplinary work and cooperation. How deep and detailed the analysis will become depends on what the goal of the research is and where the boundary of the system of interest lies. Applying a systems perspective to the study of corruption allows for exploring the dynamics assumed to be involved, recognize missing links and synergies, and where more knowledge is needed, to be better equipped to understand where future research on corruption should be directed.

Author Contributions: Conceptualization, J.G.; methodology, J.G., S.S., I.S. and K.V.R.; investigation, J.G.; writing—original draft preparation, J.G.; writing—review and editing, S.S., I.S. and K.V.R.; supervision, S.S., I.S. and K.V.R.; project administration, I.S. and K.V.R.; funding acquisition, I.S. and K.V.R. All authors have read and agreed to the published version of the manuscript.

Funding: Research was funded by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Innovative Training Network grant agreement no. 675153.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and a reference obtained from the Research Ethics Committee of University of Iceland (protocol code 17-026, 23 November 2017).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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