Sustainable evolution: What can Cultural Multi-Level Selection contribute to Sustainability Science?

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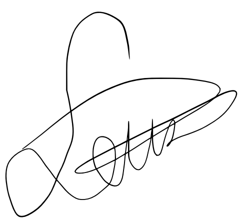

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Introduction

Perhaps the largest challenge our current generation faces is to live on our planet in a sustainable way. Even though sustainability issues like climate change, pollution and overfishing can have disastrous long-term consequences for humanity, we seem to fail to cooperate at a global scale to solve them. As early as 1979 world climate conferences have been held in order to try and solve sustainability issues, with lacklustre success up to now.

Although it appears to be a challenge that is unique to our time, similar issues regarding the sustainability of human life have actually been present on a smaller scale throughout a large period of human history. In some cases solutions were found, resulting in a sustainable way of living for humans. In other cases they were not, resulting in societal collapse (Ponting, 2007). In order to deal with these problems, the discipline of Sustainability Science has come into existence in recent decennia. This is an interdisciplinary discipline aiming to discover how to achieve sustainable social-ecological states. This objective requires not only knowledge of the planet's ecosystems, but also an understanding of human social organisation. The presence of sustainability issues throughout evolutionary history makes an evolutionary approach an interesting lens to view sustainability issues through. It might help us figure out an *ultimate* explanation of sustainability issues, as opposed to the *proximate* explanations that are commonly given. Ultimate explanations focus on *why* a certain phenomenon came into existence in our history for evolutionary reasons, while proximate are more mechanistic and focus on *how* a phenomenon takes place (Scott-Phillips, Dickins & West, 2011).

An ultimate explanation could potentially shed light on how to solve sustainability issues or prevent them from arising at all. Furthermore, understanding solutions that have been found in the past can give insight into possible solutions for the present. Concludingly, the interdisciplinary nature of evolutionary approaches might fit well with the interdisciplinary nature of Sustainability Science.

Several authors in Sustainability Science have specifically suggested Cultural Multi-Level Selection (CMLS) as an evolutionary approach that could contribute to Sustainability Science (Ellis et al., 2018; Snyder, 2020; Waring et al., 2015). Cultural Multi-Level Selection (CMLS) is an approach to evolutionary theory that holds that natural selection takes place at the level of the individual and at the level of the group. Proponents of CMLS state that culture is subject to evolutionary processes in a way that is similar to genes (Henrich, 2017 & Mesoudi, 2011). Previous work by Snyder (2020) and Ellis et al.(2018) claims that Cultural Multi-Level Selection can play a large role in explaining the emergence of sustainability issues, suggesting an understanding of this evolutionary process might also guide us towards solutions in the present. Neither Snyder or Ellis however enter into detail about the exact way CMLS can be applied in Sustainability Science in order to accomplish this. Waring et al. (2015) developed an evolutionary framework through which CMLS can possibly be applied to solve sustainability issues.

The goal of this thesis is to evaluate whether the concept of Cultural Multi-Level Selection (CMLS) can contribute to the discipline of Sustainability Science. In order to achieve this, I will analyse the ability of a CMLS approach to explain the emergence of sustainability issues through human history. Furthermore, if CMLS is to make a valuable contribution to the discipline of Sustainability Science, it should also enable us to find solutions to sustainability issues. Therefore, I will determine whether the framework provided by Waring et al. (2015) can realistically do this.

In the first chapter I will elaborate on the difficulties in defining sustainability, as well as proposing a solution. Secondly, I will further explain the concept of Cultural Multi-Level Selection (CMLS), focussing primarily on aspects that potentially apply to Sustainability Science. In the following chapter, I will demonstrate how CMLS can reveal the *ultimate* cause of sustainability issues; the reason sustainability issues tend to emerge. I argue that Snyder (2020) and Ellis et al.(2018) do an imperfect job at revealing this, suggesting their theories can both be improved upon and included in a more general evolutionary explanation. Finally I will evaluate the way Waring et al. (2015) aim to apply CMLS to create a framework for Sustainability Science. Although this framework fits well with the interdisciplinary nature of Sustainability Science, it fails to provide a way in which it can be applied accurately. Furthermore, Waring et al. are wrong to conflate cooperative behavior with sustainable behavior. Moreover, the framework is unable to provide any solutions when applied to sustainability issues that occur on a global scale. This leaves the framework unable to address the important issues like climate change and pollution.

1. Sustainability

In order to properly evaluate the contributions that CMLS could make to sustainability issues, it is important to know how exactly the term "sustainability" is used within the discipline of Sustainability Science. At a first glance, sustainability seems easy to define in a common-sensical manner. Upon further inspection though, certain problems come up. First of all, one needs to know what it is that one wants to sustain. Simply sustaining absolutely everything precisely the way it currently exists forever is not a realistic expectation. Organisms reproduce and die, ecosystems are dynamic, change is inevitable. Furthermore, our current dependence on fossil fuels is unlikely to be something we want to sustain. At the same time, however, we do likely want to sustain the availability of energy that these fossil fuels provide, which is crucial for human well-being. Therefore, academics active in Sustainability Science need to chose carefully what it is that needs to be sustained. This results in a more normative question: on what basis is to be decided what needs to be sustained? The aim could be to keep earth's ecosystems intact for the sake of nature itself, but we could also take a more anthropocentric approach and aim to keep earth inhabitable for humans.

1.1 Definitions

It is not the aim of this thesis to argue for any radical new definitions or changes in approach towards sustainability. This thesis does not wish to provide definitive answers to normative or ethical questions surrounding sustainability either. In order to judge the potential value of CMLS, all that is needed is a clear idea of what "sustainability" means in the context of Sustainability Science. The majority of papers related to the topic of Sustainability Science and CMLS do not provide a clear definition of sustainability, nor do they expand on the goals and methods of Sustainability Science (Snyder, 2020 & Kline et al., 2018). Instead, they appear to presume that what sustainability is, is understood by the reader.

While most sources in Sustainability Science do not define sustainability, others instead propose various, hardly commensurable ways to approach the concept of sustainability. This problem is illustrated by Fowke and Prasad (1996), who claim that already more than 80 different definitions of sustainability have been identified as of 1996. For instance, work by Waring et al. (2017) defines sustainability as entailing "the preservation of natural resources and the provision of human well-being" (p. 524). Not unlike others, they seem to direct their attention towards the (un)sustainability of human life. I do not intend to argue that this anthropocentric approach is ethically wrong. It is however important to note that an implicit normative decision is being made here, a decision that is generally not justified by any arguments in the literature. Other schools of thought, *deep ecology* (Devall & Sessions, 1985) for instance, argue for sustainability to deal with sustaining natural ecosystems, independently of their role in sustaining human life. As long as publications in Sustainability Science do not define sustainability, it is unclear whether they subscribe to either of these radically different approaches to sustainability.

The lack of clear definitions in some papers and the incommensurable definitions used in others make it difficult to compare and evaluate literature on sustainability, which is part of what this thesis aims to do. Furthermore, the normative question of what it is that should be sustained is hard to answer objectively from a scientific perspective and goes beyond the scope of this paper.

1.2 Sustainability Science

Due to the lack of consistent definitions of sustainability, another approach that might prove fruitful is to research the discipline of Sustainability Science itself. If authors within this discipline consistently aim to sustain the same goals, this finding could be used to form a generalized idea of what sustainability is taken to be in Sustainability Science. Kates (2011) has mapped all the publications in the field of Sustainability Science. The data shows that Sustainability Science is an extremely interdisciplinary science, with papers published in journals related to social science, biology and even engineering. Between them there is a large discrepancy in the way the subject of sustainability is approached. Kates (2011) found that 62% of articles focussed mainly on the sustainability of earth’s life support systems, while 38% directed their attention towards human wellbeing, and a few other articles primarily addressed poverty alleviation. The lack of a consistent common focus within Sustainability Science prevents us from forming one definition of what sustainability is taken to be.

1.3 A flexible approach to sustainability

The general lack of explicit definitions, the incommensurability among the definitions that are given and the inconsistent focus of Sustainability Science make it hard to form a clear definition of sustainability. Furthermore, the normative question of 'what is to be sustained' is hard to answer from a scientific perspective. Waring et al. (2015) propose a different approach to defining sustainability in order to overcome these issues. They divide sustainability into a *normative* and a *positive* component. The normative component consists of determining the social-ecological state that is desirable; the state that ought to be sustained. This component should be determined by human values, as it can not be determined scientifically. The positive component is tasked with figuring out how social-ecological states are sustained, how they come into existence and how they can be changed. The questions the positive component deals with can be answered through scientific research, so this is the component Sustainability Science should focus on, according to Waring et al. (2015).

This approach to sustainability allows us to bypass the aforementioned problems. Firstly, there is no need to solve the normative questions in Sustainability Science. Instead, the focus should lie on how to create and sustain social-ecological states that are deemed to be desirable. Secondly, the main source of the confusion regarding definitions of sustainability is the normative question of what social-ecological state it is that should be sustained. The positive component in papers in Sustainability Science however is largely the same, as all papers can in one way or another be considered to deal with social-ecological states. This makes the definition by Waring et al. very flexible, which allows us to compare different papers on the subject of sustainability without running into problems.

2. Cultural Multi-Level Selection

Now that it is clear how to approach the subject of sustainability, it is also important to determine how CMLS takes place, in order to analyse whether Cultural Multi-Level Selection (CMLS) may be applied correctly to Sustainability Science. The dominant literature involving CMLS and sustainability (Kline, Waring & Salerno, 2018; Waring et al., 2015; Waring, Goff & Smaldino, 2017) refers to entire books, as well as to some articles written by Richersen & Boyd (2005), Henrich (2004, 2017), and Mesoudi (2006, 2011) in order to explain the process of CMLS. Due to the high dependence on references to entire books (without specific page numbers), it is hard to determine the exact form in which the authors intend to use CMLS. Luckily, there is very little disagreement on CMLS between the authors referred to, so a synthesis of these works is possible.

In general, CMLS is a school of thought within evolutionary theory that argues that selection does not just take place at the level of the individual; it also concurrently takes place at the level of the group. Furthermore, CMLS incorporates the idea that culture is also subject to evolutionary processes. Because CMLS highlights the tension between the interests of the individual and the interests of the group, it is often applied to explain the emergence of large-scale human organisation and altruistic or group-beneficial behavior in humans. The mechanisms through which CMLS explains the emergence of group-beneficial behavior over selfish behavior are exactly the same mechanisms Waring et al. (2015) use to explain the emergence of sustainable behavior over unsustainable behavior. Furthermore, cultural evolution and the emergence of large-scale human cooperation are central to the ultimate causes of unsustainability that Snyder (2020) and Ellis (2018) propose. Therefore, it is important to understand the way CMLS explains large-scale human organisation and altruistic or group-beneficial behavior in humans.

2.1 Evolutionary theory

Firstly, it is important to understand the foundations of evolutionary theory, since it is an integral part of CMLS. Charles Darwin originally formulated the theory of evolution as a means to explain the diversity of organisms on earth and the apparent design of these organisms, i.e.: why these organisms are so well adapted to their environment, allowing them to survive and reproduce. This adaptedness is commonly referred to as "fitness". Darwin proposed that evolution was driven by a process of natural selection. This process follows logically from three main preconditions (Lewontin, 1970). The first precondition holds that there has to be *variation* in the traits of organisms. The second precondition states that this variation has to be *heritable*; offspring can inherit these traits from the previous generations. The third and final precondition states that there has to be some form of *competition*, a “struggle for existence”. This competition can take place as competition over different finite resources or in the form of the struggle of fending of predators. The successful organisms in this competition are those that manage to survive long enough to eventually achieve the main goal of reproduction. The outcome of this competition is determined by the traits of the participating organisms, as well as the environmental restrictions that are present. As long as forms of *variation, heritability* and *competition* are present, there will be differential reproductive success between different organisms. The organisms that successfully reproduce in a given environment are those that are able to pass on their traits to the next generation. In this way, the following generations will possess traits that increase their chance of surviving and successfully reproducing. This process of natural selection selects for traits in organisms that make these organisms adapted to their environment, which explains their apparent design. It also explains the diversity of organisms on earth, by showing how different environmental restrictions can lead to different traits being selected for (Darwin, 1859).

This process of natural selection as formulated by Darwin fails to account for some forms of altruistic behavior that are regularly observed in organisms. In evolutionary context, altruistic behavior may be defined as behavior that increases the fitness of another organism, at the cost of the fitness of the organism that displays the behavior. If the diversity of lifeforms on earth came to be through a process of natural selection, there should be close to no altruism observed, as a reduction in fitness reduces the chance an organism is able to reproduce and spread its altruistic genes. The only form of altruism that can be explained through Darwinian evolution is *reciprocal altruism.* This is a form of altruism wherein an organism performs altruistic behavior resulting in short-term fitness reduction, with the hope of the other organism eventually returning the favour resulting in a long-term fitness gain. A well-known example is that of food sharing among vampire bats (Wilkinson, 1984). Due to the unreliable success in finding prey, vampire bats sometimes have to go long periods without food. More successful vampire bats share the food they can miss with the less successful ones, increasing the chance of survival of the less successful ones. If the previously successful vampire bats turn out unsuccessful in the future, they could be saved by other vampire bats returning the favour by sharing food. This increases the long-term fitness of bats that share food, showing how traits for food-sharing could be selected for. Legitimate examples of reciprocal altruism like this are however rarely observed in non-human organisms (Hammerstein, 2003). Furthermore, forms of altruism that are not reciprocal in nature also occur. This behavior is difficult to explain using the original theory of natural selection as formulated by Darwin.

2.2 Gene-centered view

When Darwin developed his theory, he was not certain about the mechanism through which *heritable variation* takes place. As the concept of genes did not yet exist, Darwin hypothesized that the traits of organisms were passed on by a process that blended the traits of both parents, resulting in new traits in the offspring. We now know that instead of traits blending together, genes are responsible for *heritable variation,* they are genetic coding that eventually determines the traits that are passed on to the new generation. Instead of blending, genes from either parent are selected randomly and passed on to the offspring. New variations come into existence due to mutations, which are “errors” in the copying of genes from previous generations. These insights allow for a gene-centred approach to evolution, wherein natural selection can take place at the level of the gene. *Competition* takes place between genes that try to reproduce, using organisms as “vehicles” to do so. If genes produce certain traits in organisms that are beneficial to the organism, it also increases the likelihood for the genes to reproduce (Dawkins, 1976).

This gene-centred approach enables evolutionary theory to explain the emergence of altruistic tendencies towards kin that are regularly observed in organisms. If selection were to take place at the level of the individual organism, this altruistic behavior would be puzzling, as for organisms competing with other organisms in a process of natural selection, the tendency to help competitors is hardly an effective strategy and will likely be selected against. Furthermore, if a group of altruistic organisms were to exist, organisms that act selfishly could easily abuse these altruistic tendencies and outcompete these organisms, resulting in the genes for altruistic behavior not being passed on. In short, the evolutionary process selects for selfish behavior. However, Hamilton (1963, 1964) has argued that the evolution of altruistic behavior towards kin makes perfect sense when taking a gene-centred perspective. The kin of an organism is genetically related to the organism. For instance, the offspring of an organism shares roughly 50% of its genes. When taking the view that the evolutionary process is a process of genes trying to reproduce instead of individual organisms trying to reproduce, it makes sense for organisms that share 50% of their genes with each other to act altruistically amongst one another. For both organisms as vehicles for genes have the potential to reproduce partly the same genes. This way of increasing fitness by helping genetically related organisms thrive is called “inclusive fitness”. It explains why genetically related organisms cooperate and act altruistically, but it does not explain why genetically unrelated organisms in some species still behave cooperatively and altruistically in situations with little chance of reciprocity. Kin selection can also explain the existence of large-scale cooperation in certain species. Most groups of highly cooperative species have extremely high levels of genetic relatedness with their group members or consist largely of worker-type organisms that cannot reproduce by themselves (Strassman et al., 2011, pp. 4-5) leaving kin selection as a sufficient explanation for their altruistic behavior. Humans however, are likely to have lived in groups consisting of a relatively low number of kin throughout evolutionary history (Hill et al., 2014). Furthermore, not all altruism in humans can be categorized as reciprocal altruism either (Boyd & Richerson, 2006). Humans behave altruistically towards genetically unrelated strangers even in situations wherein it is unlikely for them to return the favor. This leaves kin selection and reciprocal altruism insufficient to explain the uniquely large scale at which humans cooperate.

2.3 Group selection

Natural selection can take place at the level of the individual or the gene, but in humans natural selection is likely to act at the level of the group as well. Throughout our evolutionary lineage, humans lived in social groups with distinctive group traits (*variation)*. Between these groups there was *competition*, as some groups and their members were more successful and survived and/or reproduced, while other groups died out. This suggests a high likelihood of selection taking place at the level of the group as well. If selection were to take place at the level of the group, an alternative explanation for altruism and large-scale cooperation appears that is not entirely dependent on reciprocity or kinship. As groups competed, traits that are beneficial to the group were likely selected for. The traits that benefit the group are however not necessarily beneficial to the fitness of the individual; they can generally be considered altruistic traits. Groups of individuals that behave altruistically towards members of the group are expected to outcompete groups that consist of selfish individuals, possibly resulting in selection for altruistic traits (Darwin, 1871).

However, difficulties arise when trying to explain the mechanism of *heritability* through which group traits are spread from a genetic point of view. This becomes apparent when observing what actually happens when one group outcompetes the other. One way in which intergroup competition takes places is by differential migration (Tuzin, 1976 & 2001). When a group is more successful than an other, members of the other tend to migrate to the more successful group, eventually leading to the demise of the unsuccessful group. In intergroup competition through warfare, the winning group often reproduces with the females of the losing group, integrating them into their own group (Mcdonald et al., 2012). By integrating into the successful group, the genes responsible for successful group traits mix with the genes responsible for less successful group traits. Most other forms of group competition also end up mixing the genes of successful and unsuccessful groups. This makes a process of genetic group selection in humans highly unlikely.

2.4 Cultural evolution

Although human behavior has for a part been formed by genetic evolution, it is not exclusively determined by it. Instead, human behavior is influenced by culture as well. In fact, culture plays such a uniquely big role in behavior that humans depend more on it for survival than any of our primate relatives (Henrich, 2017, pp. 22-33). This makes culture a crucial phenomenon to study when trying to make sense of human behavior.

The proponents of CMLS argue that culture is also subject to evolutionary processes. In this context culture is defined as “information acquired through social learning”. Information in this case can be interpreted in a broad sense to refer to norms, skills, knowledge, etc. Social learning is a process of imitation that allows individuals to acquire cultural knowledge (Boyd, Richerson & Henrich 2011). Certain cultural practices can provide solutions to the adaptive problems that humans encounter. The more adaptive cultural knowledge an individual possesses, the more likely the person is to survive and reproduce. Throughout human evolutionary history, however, it has presumably not always been clear whether certain cultural practices were adaptative. This problem is solved partly by the human tendency to disproportionally imitate the behavior of the more successful humans in the group; the humans with *prestige* (Henrich & Gil-White, 2001). This does not guarantee the imitation of adaptive cultural practices, but it significantly raises the likelihood for it to occur. As cultural practices are discovered, modified and copied if beneficial over multiple generations, culture is accumulated over time resulting in large amounts of cultural knowledge. This cumulated amount of adaptive culture acquired through social learning is much higher and more reliable than could be acquired through individual learning in a single lifetime. The way cultural practices emerge and spread may be considered an evolutionary process, because it satisfies the three preconditions posed by Darwin. First of all, it is a fact that there is a great amount of *variation* when it comes to culture. Secondly, these cultural ideas are *heritable* through the process of social learning. Furthermore, there is a form of *competition* between cultural ideas. Culture is selected to be acquired through a process of social learning, depending partly on the prestige of the agents performing cultural practices. Not does direct competition between cultural ideas take place, these cultural ideas also indirectly compete through the process of natural selection as adaptive cultural traits are more likely to spread due to their effect on survival and reproduction of individuals (Mesoudi, 2011, Chapter 2).

2.5 Integrating cultural evolution and group selection

Proponents of CMLS integrate the ideas of group selection and cultural evolution, proposing a form of cultural group selection. Cultural group selection does not run into the same issues that genetic group selection runs into regarding *heritability*. Cultural group selection holds that mainly the cultural group traits decide the outcome of group competition. Because these traits are not genetic, it now becomes possible to integrate members of other groups without mixing group traits. Instead, the more successful cultural group trait gets adopted by the newcomers. This results in an evolutionary process in which the group with the most adaptive cultural traits grows and outcompetes the others. Cultural group selection is often used as a way to give an ultimate explanation of human altruism and large-scale human cooperation. Cultural selection pressures at the level of the group do not exist in isolation, selection pressures at the level of the individual or gene exist concurrently (Henrich, 2004, pg. l3). This is an important aspect of Cultural Multi-Level Selection (CMLS). CMLS recognizes that there is often tension between the traits that are adaptive to the individual and the traits that are adaptive to the group.

Cultural multi-level selection provides us with the tools to face the challenge of explaining the large scale at which humans cooperate, as well as explaining altruism among non-kin in situations with little chance of reciprocity. As groups compete in a process of cultural group selection, the groups with the most adaptive cultural traits will likely spread their traits. It is most important for the success of the group that its individual members do not act selfishly, but act for the benefit of the group instead; that they act *cooperatively*. According to Bowles and Gintis (2003), this cooperative behavior is incentivised and enforced through social (cultural) institutions. These institutions consist of rules that tend to punish selfish behavior and/or reward cooperative behavior, making the selfish strategy no longer the optimal strategy for the individual. As group members behave more cooperatively due to these institutions, group fitness increases, and these cultural institutions are more likely to spread. This structure can be found in many of the institutions that spread near-universally among human societies like marriage, borders and property laws (Vlerick, 2016). Our current societies in which humans live together on an incredibly large scale is highly dependent on cultural institutions that regulate behavior. Without these institutions, cooperating at such a large scale would be impossible.

3. The ultimate causes of unsustainability

Now that we know how the process of CMLS takes place, as well as how to approach the subject of sustainability, we can start evaluating whether it can be applied fruitfully in the discipline of Sustainability Science. Scientists argue that we are now living in the Anthropocene, the epoch in which humanity is considered to be the primary force shaping the earth´s ecosystems (Waters et al., 2016; Gowdy & Krall, 2013). As human populations grew they started putting more strain on their natural environment in order to maintain themselves, resulting in difficulties for non-human nature as well as human life itself. Although the (proximate) mechanisms of these sustainability issues are often well-known, little time is spent explaining *why* humanity continuously encounters these sustainability issues. I argue along with Ellis et al. (2018) and Snyder (2020) that an ultimate explanation of our ability to shape the environment and our tendency to encounter sustainability issues can best be found through the lens of Cultural Multi-Level Selection.

3.1 Anthroecological theory

Anthroecological theory argues that the human capacity to shape the environment evolved through a *reciprocal* evolutionary process between growing human populations and ecosystem engineering (Ellis, 2015). Ellis et al. (2018) argue that this reciprocal process is a process of Cultural Multi-Level Selection that acts mainly on cultural practices that facilitate the human capacity for ecosystem engineering and sociocultural niche construction. Ecosystem engineering is the general practice of changing the ecological environment in order to obtain evolutionary success. Sociocultural niche construction is a uniquely human way of altering the sociocultural environment in order to be evolutionarily successful. Whereas most cases of ecosystem engineering in non-human animals can be considered genetically evolved tendencies, human ecosystem engineering tends to find its origin in culture (Smith, 2007). Beavers build dams instinctively, while humans acquire the ability to build houses, chop down trees or grow crops through social learning. As mentioned in chapter 3, cultural group selection selected for institutions that incentivize unselfish, pro-group behavior, that enabled humans to live together on larger scales. These institutions can be considered forms of sociocultural niche construction. Ellis et al. (2018) argue that the intensification of ecosystem engineering and sociocultural niche construction has led to growth in the populations that human groups were able to sustain. As human populations grew, more advanced forms of ecosystem engineering and sociocultural niche construction were needed to sustain human life. This is a runaway evolutionary process; a long-term system of positive feedback loops between traits that accelerate the rate at which the traits co-evolve. Ellis et al. (2018) propose that this self-reinforcing system of positive evolutionary feedbacks between ecosystem engineering & sociocultural niche construction intensity on the one hand, and population size on the other, is the reason humans have evolved into a species that radically shapes its environment. Furthermore, many forms of ecosystem engineering and sociocultural niche construction directly result in selection pressures for even more intensive niche construction. Soil tillage for instance results in a long-term decline in soil fertility, creating a selection pressure for more advanced forms of agriculture like manuring or multi-cropping (Matson et al., 1997, Harris & Fuller, 2014).

Ellis et al. illustrate this process by providing archaeological evidence for the co-evolution of ecosystem engineering & sociocultural niche construction on the one hand, and population size on the other. The agricultural revolution occurred in similar ways abour 20 times worldwide, consisting of similar new forms of ecosystem engineering & sociocultural niche construction, and resulting in similar patterns of population growth in all cases (Fuller et al., 2014). Occurrences of urbanisation throughout human history also resulted in parallel developments. Ellis et al. (2018) state that while populations grew, more humans performed non-farming specialist roles that allowed for more advanced craftsmanship, which spurred the development of sociocultural niches needed to redistribute food. At the same time, more intense farming practices were developed to supply the non-farming population and allow for further population growth.

This explanation for long-term social-ecological change in the Anthropocene has its limitations. First of all, its main focus on ecosystem engineering and sociocultural niche construction might be blinding us for other causes of social-ecological change. A runaway evolutionary process between ecosystem engineering and sociocultural niche construction might very well result in social-ecological change, but it is not the necessarily the only possible direct cause of it. Throughout evolutionary history, simply being an evolutionarily successful species can already be the cause of large-scale ecological change, regardless of the species' predisposition for ecosystem engineering. If a predator species is highly successful, this will lead to the extinction of the prey animals and a radical disruption of the ecosystem, possibly resulting in long-term ecological change. Secondly, while Ellis et al. intend to apply CMLS to determine the cause of long-term social-ecological change, their explanation is not very evolutionary in nature. The positive feedback loop between ecosystem engineering and sociocultural niche construction on the one hand, and population growth on the other, could just as well be a non-evolutionary description of how cultural developments took place that led to the Anthropocene. Using evolutionary terminology to describe this process does not provide any additional explanative power. It is also the case that the explanation by Ellis et al. can hardly be considered an *ultimate* explanation. Instead of focussing on the underlying driving forces, Ellis et al. have emphasized the mechanism through which social-ecological change takes place, resulting in an explanation that can be considered to be partly proximate.

The explanation by Ellis et al. is also insufficient if it is used as a way to explain the emergence of unsustainability. Although Ellis et al. primarily claim to apply the CMLS approach to explain long-term ecological change in the Anthropocene, they suggest towards the end of their paper that this understanding can be used to understand (un)sustainability issues as well. What Ellis et al. believe (un)sustainability to be and how exactly their theory could do this is not mentioned. On the one hand, Ellis et al. (2018) refer to sources that approach sustainability through an anthropocentric lens (Schill et al., 2016; Waring et al., 2017) when stating:

> ABM (agent based models) developed using a CMLS framework have . . . demonstrated linkages among environmental conditions and individual and group behaviors, norms, institutions, and sustainable resource use regimes; cultural group selection has also been shown to facilitate sustainable societal behaviors (Waring et al., 2017: Schill et al., 2016). (p. 124)

On the other hand, Ellis et al. (2018) Suggest their approach:

> . . . has the potential to investigate the key questions of sustainability science. Is human sociocultural evolution sustainable over the long term? How will sociocultural evolution shape future trajectories of social and environmental change? How can these evolutionary processes be guided towards better outcomes for both humanity and nonhuman nature? (p. 125)

Therefore, it is ambiguous whether Ellis et al. consider sustainability through an anthropocentric lens or whether they consider sustainability to refer to sustaining all of nature for the sake of nature itself.

If Ellis et al. were to consider sustainability to refer to sustaining all of nature for the sake of nature itself, any form of social-ecological change could potentially be considered unsustainable. Determining the exact point at which social-ecological change becomes unsustainable would be very difficult from this point of view. If viewed through an anthropocentric lens, sustainability entails the sustainability of human survival or wellbeing. When considering the suggestion that (un)sustainability is a result of the social-ecological change that develops through a positive feedback loop between ecosystem engineering and sociocultural niche construction from this anthropocentric perspective, another problem emerges. Not every form of social-ecological change inherently has to lead to sustainability issues. The Montreal Protocol signed by all members of the United Nations in 1987, for instance, has resulted in a reduction in the use of ozone-depleting chemicals, allowing the ozone hole to shrink (Velders et al., 2007). If social-ecological change were inherently unsustainable, we could not solve sustainability issues by making social-ecological changes at all. An *ultimate* explanation of the human tendency towards unsustainability would at least need to explain what it is that makes some forms of social-ecological change unsustainable and others not, as well as why the unsustainable one tends to emerge.

3.2 An energetic approach to the evolution of unsustainability

Anthroecological theory as proposed by Ellis et al. can partly explain why humans have evolved to shape their environment, but it does not specify how this leads to sustainability issues. Snyder (2020) proposes a different way to explain the human tendency towards unsustainability using CMLS, solving some of the problems that the theory by Ellis et al. runs into. Snyder attempts to provide a more generalizable and more ultimate evolutionary explanation by linking energy extraction to fitness.

Firstly, he clearly defines what he means by "unsustainability". Snyder employs a "continuum of unsustainability", consisting of states a human population can be in. This continuum ranges from a state of general unsustainability to a state of socio-ecological crisis to a state of socio-ecological collapse. In a state of unsustainability, a human population extracts growing amounts of energy and materials from the environment in order to maintain itself and grow. This state can lead to a state of socio-ecological crisis, wherein a human population has expanded beyond its capacity to extract energy and materials from the environment in order to grow or maintain itself, endangering the population and its wellbeing. A state of socio-ecological crisis can eventually lead to a state of socio-ecological collapse, which consists of a "rapid decline in the population and/or development of a society due to a combination of ecological and social factors" (Snyder et al, 2020, pp. 1087-1088). Throughout history, human societies have tended to live somewhere along this continuum of unsustainability. So, Snyder approaches sustainability from a more anthropocentric perspective, seeking to explain why human societies throughout history tend to struggle with sustainability issues that could eventually threaten the existence of the societies themselves.

Snyder takes an "energetic" approach to anthroecological theory. Instead of focussing on mechanisms through which social-ecological change takes place like niche construction or ecosystem engineering, Snyder aims to emphasize the underlying causes driving the process. He argues that the main driver behind human unsustainability is the tendency to maximize energy extraction from the environment. Certain schools of thought in evolutionary theory closely link energy extraction to the evolutionary concept of fitness, in order to provide a more quantifiable and physiological description of the process of natural selection (Brown et al., 1993; Garland & Carter, 1994) . In general, fitness is seen as the ability of an organism to produce offspring, an ability that is selected for through natural selection. However, there is very strong correlation between energy extraction and reproductive power, as energy extraction is needed to reproduce. The energetic definition of fitness considers fitness to be the ability to extract energy from the environment and convert it into offspring. Proponents of the energetic approach argue that the ability to reproduce can be expressed in terms of energy extracted from the environment. Most organisms exclusively use the extracted energy somatically; their energy extraction is equal to the amount of calories they consume. The more calories are available, the more offspring can be produced. Humans are also able to convert extra-somatic energy sources into fitness. For instance, fossil fuels can be converted into fertilizer to increase food production, or wood can be burned in order to protect from predators. These forms of energy extraction also increase the number of offspring that can be produced. Furthermore, natural selection generally maximizes energy extraction (Pianka, 1970). Energy extraction and reproductive power are strongly correlated, but they are not exactly the same thing. Therefore, energetic definition of fitness should not be accepted as a literal definition, but it can be used as a tool to express fitness quite accurately in befitting contexts.

According to Snyder's energetic approach, humans and other organisms are in constant competition to maximize the amount of useful energy extracted from the environment. Generally, the more energy is extracted, the more likely an organism to reproduce successfully. Humans are however not only subject to selection acting on genes, cultural selection is taking place concurrently. The process of cultural selection selects for cultural ideas or practices that maximize energy extraction as well. These processes also take place at the group level. This set of ideas is congruent with Lotka's maximum power principle (Lotka, 1922). This principle states that open systems tend to maximize the rate at which they can absorb useful energy from the environment. Notice that open systems can refer to organisms, but groups of organisms can also be considered an open system.

Snyder argues that the evolutionary process leading to increases in energy extraction occurs at a faster pace in humans than in other organisms for three reasons. Firstly, the nature of cultural evolution increases the rate at which energy extraction is maximized. As cultural ideas don´t depend on genetic reproduction to spread to the next generation, cultural ideas can spread to new generations far more quickly. Furthermore, cultural mutations can be intentionally generated and spread at the group level, potentially increasing the likelihood for adaptive culture to spread and the rate at which it does. Therefore, cultural selection for energy extraction in humans occurs at a faster pace than genetic selection does. (Perreault, 2012) Secondly, Snyder proposes an evolutionary feedback loop that is similar to the one proposed by Ellis et al. (2018) to explain a further increase in the rate at which human energy extraction evolved. According to Snyder, increased energy extraction by a society leads to higher carrying capacity, i.e., the ability to sustain larger populations. An increase in carrying capacity leads to an increase in population size, which in turn increases the rate at which a society is able to produce cultural innovations, speeding up the process of cultural evolution. These cultural innovations are able to further increase the amount of energy extracted from the environment, completing the positive feedback loop. Thirdly, genetic psychological predispositions that evolved in palaeolithic humans are also presumed to play a part in the fast rate of energy extraction maximization. For instance, humans have evolved the tendency to determine value of goods on the basis of the amount of goods they own relative to others, instead of on the absolute amount of goods. Trying to acquire more goods or resources than others could be adaptive because it increases status, which increases the chance to find a mate and reproduce (Van Vugt et al, 2014). Snyder would argue that acquiring resources and goods are a form of energy extraction. The tendency to extract more energy from the environment relative to others is another proposed cause for the high rate of energy extraction by humans, possibly being a driving factor in the cultural multi-level evolutionary process that increased human energy extraction.

Human societies continuously encounter states of unsustainability as a result of this fast-evolving rate of energy extraction. Opportunities to extract energy are limited and zero-sum. When more energy is extracted by one organism, less total energy is necessarily available for other organisms. This puts a selective pressure on other organisms in the environment to extract more energy from it in order to survive and reproduce. Due to the increased rate at which humans evolve their capacity for energy extraction, more slowly evolving organisms in the environment limited to genetic evolution eventually fall behind. This can lead to extinction of species of animals and plants that potentially play an important role in the ecosystem, which could negatively influence the ability of humans to extract energy from this ecosystem. Furthermore, the limited potential amount of energy that can be extracted from the environment puts an upper limit to the amount of energy a society can produce. The fast rate at which human energy extraction evolves could see humans reach this upper limit, resulting in populations exceeding carrying capacity. Both the extinction of genetically evolving organisms in the environment and the upper limit to energy extraction can lead to difficulties in sustaining increasing human populations, potentially resulting in socio-ecological crises or even collapse. Snyder thus argues that sustainability issues arise because organisms and societies with higher rates of energy extraction, even if unsustainable, outcompete other organisms and societies.

Snyder’s approach has some advantages over Ellis et al.. First of all, it provides a clear definition of what unsustainability is taken to be. It also provides an ultimate explanation of sustainability instead of taking a more proximate, mechanistic approach. This approach does not exclude sociocultural niche construction and ecosystem engineering, to the contrary, it can incorporate them as methods used to maximize energy extraction. The same can be done with other proposed mechanisms that cause unsustainability, which is an advantage of the energetic approach by Snyder. Furthermore, Snyder’s approach does not rely on the idea that humans have unique capacities for sociocultural niche construction or ecosystem engineering. It is not a process unique to humans during the agricultural revolution or urbanisation either. Instead, the energetic approach allows for a more universal application; every organism evolves to maximize energy extraction, and any process of cultural evolution also works towards this end. There is also more attention for the role that the different rate of cultural and genetic evolutionary processes plays, which Ellis et al. ignore.

3.3 A non-energetic approach to the evolution of sustainability

Although Snyder takes a step in the right direction with the energetic approach, I argue that an even more universally applicable explanation of the tendency to encounter problems with sustainability is possible, without relying on the incorrect assumption that reproductive power equals energy extraction. Instead, basic CMLS is sufficient. Furthermore, Snyder underestimates the rate at which cultural evolution takes place.

Snyder states that cultural evolution occurs at a faster pace because it does not rely on genetic reproduction and it can be steered intentionally. This is however only a small part of the entire picture. Cultural ideas can not only be passed on to the next generation more swiftly, they can also be spread horizontally within the same generation, as well as from new generations to previous generations that are still alive. Furthermore, the spread of cultural adaptations is independent of reproduction the spreading of mutations of cultural ideas can take place at any time in human life.This results in an even more dramatic increase in the speed with which adaptations can spread.

The notion that *unique* human psychological tendencies to value status, wealth or resources relative to other humans might be driving the evolution of energy extraction maximisation is incorrect. During the entire process of evolution, natural selection selects for the traits of organisms that are more successful *relative* to other organisms in their environment. Fitness is no absolute value, it is always relative to other organisms. The male peacock does not need a tail of specific beauty or size, it needs one that outperforms the tails of other male peacocks in this respect. A cheetah does not need to be able to run 200 mph, it needs to be able to run fast enough to catch up to an antelope before another cheetah does. It is therefore not uniquely human to evaluate indicators of success relative to others, it is inherent in the process of evolution itself.

Snyder uses an energetic approach to fitness as a tool to explain the human tendency towards unsustainability. Although this tool serves him well in this case, fitness is not usually understood as the ability of an organism to extract energy from the environment. I would argue that therefore, if available, an explanation that does not depend on an energetic definition of fitness would be preferable. Firstly, the energetic approach is not necessary to explain the way unsustainability occurs. Human behavior evolving faster than the behavior of other organisms is essentially enough to explain the difficulties these other organisms face. These genetically evolving biotic counterparts are adapted to their environment. As human cultural evolution occurs more quickly, and this evolution allows for a massive increase in population size, this in itself is a radical change to the environment that includes these other organisms. As this change occurs as a result of cultural evolution, the organisms cannot adapt quickly enough to their new environment as a consequence of the slower process of genetic selection. This in turn results in the extinction of species, including organisms that play a key role in the ecosystem in which humans flourish, with disrupting consequences for the environment to which humans are adapted, which can result in difficulties for sustaining human societies as well. This process provides a sufficient explanation for less anthropocentric definitions of unsustainability, but it also explains how unsustainability for human societies can emerge, without requiring an energetic definition of fitness.

Snyder does however offer another way in which anthropocentric unsustainability can occur through the energetic approach. There is necessarily an upper limit to the amount of energy that can be extracted from the environment, which could lead to human populations outgrowing their carrying capacity, resulting in socio-ecological crises. This explanation is crucial, and it requires us to think in terms of energy extraction. It does however not require us to define fitness as the amount of energy extracted. Previous work by Ellis et al. (2015) shows a very strong correlation between the scale at which cultural evolution takes place and the amount of energy that is extracted in the course of human evolutionary history. As adaptive cultural ideas and practices increase, so does the amount of energy extracted. Thinking of this as a simple correlation between cultural evolution and energy extraction is sufficient for explaining the sustainability issues that arise due to the upper limit of extractable energy through ordinary CMLS, without depending on an energetic definition of fitness.

Snyder, as well as Ellis et al., propose a positive feed-back loop relating to population size that is instrumental to the development of the impact that humans have grown to have on their environment. Ellis et al. limit themselves too much to the mechanisms of sociocultural niche construction and eco-system engineering, while Snyder unnecessarily employs a controversial energetic definition of fitness. However, a simpler but similar positive feedback loop could suffice, as long as it explains a further increase in the pace of cultural evolution. This type of feedback loop has already been proposed multiple times by scholars engaging with CMLS to explain human cultural evolution and increase in population size (Henrich, 2004; Powell et al., 2009). As societies increase in population, they are able to produce more cultural adaptations. These cultural adaptations can be innovations that increase food production, but they can also be sociocultural institutions. Cooperative behavior incentivized by sociocultural institutions and increases in food production allow for population growth, which in turn further accelerates cultural evolution. Note that this further accelerated rate of cultural evolution can explain the tendency towards unsustainability if we recognize that it correlates with energy extraction.

This approach relying purely on CMLS does not exclude the explanations Ellis et al. and Snyder provide. Not only do the rate of cultural evolution and energy extraction correlate, sociocultural niche construction and ecosystem engineering also increase as cultural evolution occurs on a larger scale (Ellis, 2015, Figure 3, p. 305). Sociocultural niche construction and ecosystem engineering are both practices that evolved through cultural evolution in humans (Smith, 2007), so they can be considered culture and included in the CMLS view on human unsustainability. Furthermore, Snyder’s energetic approach can be used as a more detailed description of the role energy extraction plays in encountering sustainability issues, without denying the underlying process of fast-paced cultural evolution that drives it.

4. The CMLS framework proposed by Waring et al.

The previous chapter has shown that CMLS can help explain the emergence of sustainability issues in the course of human evolutionary history. But, it is still not clear how CMLS might be applied to solve present day sustainability issues. Waring et al. (2015) propose a CMLS sustainability framework to ". . . help achieve desirable social-ecological states by generalizing lessons across contexts and improving the design of sustainability interventions" (p. 1). In this chapter I will provide an overview of this framework and evaluate whether this framework can contribute to solving sustainability issues.

4.1 Why CMLS?

According to Waring et al., frameworks currently used in Sustainability Science apply only to certain contexts or certain levels of organization, making it hard to generalize patterns of sustainable behavior. They aim to fulfil the need for a framework that can draw generalized conclusions concerning causal patterns in different social-ecological contexts in order to describe the emergence of (un)sustainable behavior. The goal of this framework is ultimately to provide a way to design more effective solutions to sustainability issues. Waring et al. argue such a framework should possess certain qualities.

Firstly, they aim to create a framework that focusses only on the positive component. In their view, such a framework should explain the emergence and persistence of social-ecological states. It should not determine the desirability of specific social-ecological states. As suggested in the previous chapter, cultural change is the main driver behind social-ecological change. Therefore, Waring et al. argue that such a framework must be able to model the process under which cultural change takes place in order to explain the emergence and persistence of social-ecological states. In their view, sustainability issues and their possible solutions can often take place at multiple different, interacting, levels of organization. The negative consequences of plastic waste for instance, might be felt by individual fishermen, but not by the multinational companies that produce plastic waste. Also, plastic waste might be reduced through individual recycling behavior, through companies that no longer produce plastic packaging or through governments implementing the collection of plastic waste. The complex multi-level nature of sustainability issues makes it very challenging to design effective policy interventions (Gupta, 2007). Waring et al. argue that therefore, any such framework needs to elucidate these complex multi-level interactions. Waring et al. argue that CMLS is well equipped to describe multi-level interactions, model cultural change and explain the emergence of social-ecological states.

According to Waring et al, there is a fourth important quality such a framework should posses. This quality requires a more detailed explanation. Waring et al. argue that the majority of sustainability issues, and especially the most pressing ones, consist of cooperation dilemmas. Examples of this are sustainability issues relating to climate change, deforestation, overfishing or pollution. A cooperation dilemma is a situation in which the interests of the individual organism conflict with the interests of a group. A textbook example of a cooperation dilemma that applies well to the subject of sustainability is *the tragedy of the commons*, which describes a hypothetical scenario that resembles a type of cooperation dilemma that is likely to have occurred often through human evolutionary history. In this scenario, there are multiple farmers that share a field on which their cattle can graze. It is in the interest of each individual farmer to let his cattle graze on this field as much as possible. However, if all of these farmers decide to follow their individual interest and let their cattle graze on the field maximally, the field will eventually become barren. A barren field can not provide food to any of the farmers' cattle, which is therefore detrimental for the individual interests of all the farmers involved. To avoid this problem, the farmers might cooperate and decide to provide their cattle with the minimal amount of food required by each letting their cattle graze the field only once a week, sustaining the food source. Under this agreement however, a farmer following his individual interests would still do best to let his cattle graze as much as possible. This would provide his cattle with an abundance of food, whereas the more restrictive grazing of the cattle of the other farmers would help secure the longevity of the food source. Therefore, if all the farmers are rational beings serving their individual interests, the cooperative solution will never really persist as farmers will drift towards the more selfish strategy. A similar pattern can be seen for instance in the sustainability issue of climate change. Although climate change mitigating practices are beneficial to all countries on earth, it is even more beneficial for a country to selfishly avoid these costly practices while reaping the benefits of the more cooperative countries that do employ them. Therefore, countries might tend to drift towards more selfish strategies. In order for sustainable behavior to emerge, parties have to choose the cooperative strategy in a sustainability cooperation dilemma. Waring et al. argue that because the most pressing sustainability issues consist of cooperation dilemmas, and the emergence of sustainable behavior depends on cooperation, the framework should be able to provide an insight in the emergence or evolution of cooperation. As shown earlier in this thesis, CMLS is able to explain the evolution of cooperative behavior in humans.

The demands Waring et al. place on their framework seem reasonable, and it is understandable why they consider CMLS a prime candidate to fulfil these demands In order to evaluate this candidate however, it is important to understand how exactly Waring et al. suggest CMLS can be applied to sustainability issues.

4.2 The CMLS framework

According to Waring et al., a large majority of sustainability issues takes the shape of cooperation dilemmas just like the tragedy of the commons, in which sustainable behavior requires cooperative behavior. As explained in the second chapter of this thesis, the emergence of cooperative behavior in humans can be explained by a process of selection for group-beneficial cultural traits acting at the level of the group. Waring et al. (2015) argue that ". . . in environmental dilemmas cultural group selection on cooperation provides an excellent candidate mechanism for the emergence of cooperative environmental behavior" (p. 10).

When selection takes place at the group level, the more cooperative (and thus) sustainable strategy is likely to be chosen by parties in sustainability cooperation dilemmas. Selection does however not only take place at the level of the group, and there are always tensions between group interests and individual interests. It is therefore not enough to state that group selection has to take place, the group level furthermore has to be the *dominant* level of selection in order for cooperative sustainable behavior to emerge. Human societies consist of hierarchical groups at many organizational levels (e.g., individual, family, neighbourhood, city, state, country, etc.). Waring et al. (2015) state that these ". . . hierarchical levels of human social organization may operate as levels of selection in the evolution of cultural traits, organisational features and environmental behavior" (p. 4). Thus, human societies consist of groups and subgroups that interact as levels of selection similarly to the way individuals and the group interact. In order for a sustainability dilemma to be solved then, according to Waring et al., selection needs to be dominant at a level above the level at which the dilemma occurs in order for sustainable cooperative behavior to emerge. Waring et al. (2015) claim that:

> Group selection will tend to be stronger than individual selection when (1) a greater fraction of total trait variation occurs between groups than between individuals, (2) the relative benefits to the group are greater, and (3) the costs to cooperative individuals are lesser. (p. 4)

Thus, the dominant level of selection might be determined by analysing trait variation and the ratio of costs and benefits between groups and individuals ((1),

(2) & (3)), providing insight in the emergence of cooperative sustainable behavior.

Waring et al. argue that this CMLS framework for understanding the emergence of cooperative sustainable behavior has certain advantages. Firstly, it helps to model the conflicts between multiple levels of selection. It should also be able to consistently organize facts relating to the emergence of sustainable behavior and social-ecological states in different contexts in terms of costs (3), benefits (2), and trait frequency (1). Furthermore, this framework is descriptive in nature; it does not determine the desirability of specific social-ecological states. Another benefit of CMLS approach suggested by Waring et al. (2015) is that it can provide the following rule of thumb:

> (A) When the dominant level of selection is below that of the dilemma, selection on individuals favors individualistic strategies, non-cooperation, resulting in an unresolved dilemma. (B) When the dominant level of selection is above that of the dilemmas, selection on groups favors group-functional traits, collective action, individual cooperation and a resolution to the dilemma. (p. 4)

They suggest that the insights regarding the emergence of cooperative sustainable behavior expressed in this rule of thumb can help identify the appropriate level for policy intervention. This is one of the challenges faced when trying to design solutions to sustainability dilemmas (Gupta, 2007). At this point in their article it is not very clear how exactly this rule of thumb is meant to help design policy interventions.

Waring et al. choose not to provide a detailed explanation of the nature of the selection process through which sustainable cooperative behavior supposedly emerges. It is clear that the process selects for cultural traits, which might also take the shape of organisational features and environmental behavior. As explained in chapter 2, these cultural traits might be selected for because individuals or groups with these traits are more successful in an evolutionary sense; they are more likely to survive and reproduce and thus spread the cultural traits and behavior. It is also possible for these successful cultural behaviors to be selected for through the process of other groups or individuals copying them. This is a genuine evolutionary process of selection. However, Waring et al. also suggest that competition at other organizational levels and in different domains, between private enterprises for instance, can lead to a process of selection for certain cultural traits and organisational features. In the the case of private enterprises, this selects for traits that result in an increase in profit, not for traits that enhance the ability to survive and reproduce. Furthermore, organisational features do not only emerge from a blind process of selection like mentioned in the previous paragraph, private enterprises tend to make conscious decisions about them as well. Because of this, we are no longer dealing with a blind evolutionary process of selection in the Darwinian sense.

There is a complex debate to be had about whether such cultural change in human organizations is caused by a genuine evolutionary process of selection.

Waring et al. (2015) choose to sidestep this discussion by making the following claim:

> Conflicts between levels of selection are a generalizable theoretical tool, applying to any social dilemma at any level, whether between nations in Europe or between children on a sports team. The evolutionary interactions between levels have been modelled in multiple ways (Frank 1995, Simon et al. 2013), and the same formalisms can serve as a general model for cultural change (El Mouden et al. 2014). (p. 3)

So, they avoid making a claim about whether the emergence of cooperative behavior that solves cooperation (social) dilemmas is effectively *caused* by a genuine evolutionary process. Instead, it seems Waring et al. consider the emergence of cooperative sustainable behavior in cooperation dilemmas *analogous* to the CMLS explanation of cooperative behavior. They claim that the CMLS explanation of the evolution of cooperative behavior might serve as a generalized tool that applies to cooperation dilemmas. I will therefore not argue whether Waring et al. actually explain the emergence of cooperative behavior in cooperation dilemmas through a genuine process of CMLS. Instead, I will evaluate the usefulness of their CMLS framework as a tool for understanding the emergence of (un)sustainable behavior and for designing effective sustainability interventions.

4.3 The CMLS framework applied

From their explanation, it is not very clear yet how exactly the framework is to be applied. In order to demonstrate the way this framework is to function and illustrate its advantages, Waring et al. apply the CMLS framework to specific case narratives. In this thesis, I will make use of one of these case narratives in order to elucidate the case Waring et al. make for their framework. There are some dubious elements to the demonstration by Waring et al., which I will criticize later in this thesis.

Waring et al. examine traditional marine tenure institutions in Fiji through a CMLS lens. Prior to British colonization inhabitants of Fiji followed strict rules regarding harvesting in fishing, and this resulted in a sustainable way of living. Because of colonization, the institutions enforcing these rules collapsed, which resulted in overfishing and sustainability issues. Waring et al. point to three relevant levels of organization that could function as potential dominant levels of selection. Selection could take place at the level of the individual forager, of village chiefdoms or of the entire nation-state Fiji. Traditionally, village chiefdoms enforced institutions to limit marine foraging which resulted in a more sustainable pattern of resource consumption. These institutions included rules regarding reef ownership, prohibitions on specific marine resources temporary reef closures. For the individual forager, the most beneficial behavior would be to maximize the amount of resources extracted from the environment. For the village chiefdom however, sustainable resource consumption appears to be optimal. From a CMLS perspective, these institutions can therefore be seen as cooperative sustainable group traits, which solved a sustainability dilemma.

Waring et al. suggest that the institutions regulating foraging behavior are cultural traits that were selected for, because the village chiefdoms constituted the dominant level of selection. This was the case, because the villages directly competed with one another through warfare. Through warfare villages could acquire new fishing territories, but it could also lead to death and the loss of territories. This form of competition raises the stakes, resulting in higher benefits to the successful group (as well as higher costs to unsuccessful groups) (2), which potentially outweigh the costs of cooperative behavior for individual foragers (3). As proposed by Waring et al., this makes the group more likely to be the dominant level of selection and thus cooperative sustainable behavior more likely to emerge. Furthermore, sustainable behavior and resource conservation might have been especially adaptive for village chiefdoms in Fiji due to the harsh and unpredictable local climate. Storms and extreme droughts could suddenly reduce available resources, which would be detrimental for groups that overharvested the fishing waters. Having sustainable reliable fishing practices also pays off in case invasions by other chiefdoms reduce the availability of resources. Because armed conflict on Fiji was resource intensive and it was easier to defend a village than to conquer it (Derrick, 1946), it was likely a more successful strategy for groups to defend their villages and consume their resources sustainably. All this, Waring et al. (2015) argue, ". . . would favor the persistence and even the expansion of villages that enforced more sustainable strategies for resource consumption" (p.

5). Therefore, the cooperative sustainable institutions regulating foraging behavior emerged because they were selected for at the level of the group.

Under British colonization warfare between the villages on Fiji was suppressed, and Fiji got in contact with the global commercial fishing market. The suppression of warfare lowered the stakes of group competition on Fiji, resulting in less potential benefits to successful groups, as well as less potential costs to unsuccessful groups. Participating in the global commercial fishing market also created an incentive for individual foragers to maximize the resources they extracted from the environment, as the surplus fish could be sold in order to create wealth or obtain modern conveniences. Furthermore, Fiji could now compete on the global fish market as nation. These developments likely changed the ratio between group benefits (2) and individual costs to cooperative sustainable behavior (3), which changed the dominant level of selection in Fiji. The power of village chiefs dwindled and institutions regulating sustainable resource use could no longer be held in place by them. This resulted in the inhabitants of Fiji competing to maximize resource extraction, causing unsustainable fishing practices to be selected for.

4.4 Using the framework for solutions

Not only do Waring et al. consider their framework to be a way to interpret cases from the past and organize facts related to social-ecological change and the emergence of sustainable behavior, they also suggest ways its rule of thumb can be used to design effective solutions to present day sustainability issues. In the following paragraph I will describe these suggestions. It is however unlikely for the following suggestions for designing solutions to be effective, which I will demonstrate later in this thesis.

The first suggestion made concerns targeting the right level of selection for the sake of policy making. For instance, research shows that energy conservation policies in residential neighbourhoods work best when aimed at individual behavior (Ayres et al., 2013). In college dormitories however, energy conservation policies aimed at group behavior prove more effective (Petersen et al., 2007). If we follow Waring et al., this is likely due to a difference in the dominant level of selection for the trait "energy conservation behavior". The savings from energy conservation benefit the whole coresident social group in a dormitory, whereas the benefits of energy conservation in residential neighbourhoods only effect individual households. Therefore, selection for energy conservation behavior is more likely to be dominant at the level of the group in college dormitories. Waring et al. (2015) conclude that ". . . identifying the dominant level of selection in a given system may help guide future policy efforts"(p. 8). They claim this is something the CMLS framework could facilitate.

A second type of solution to sustainability issues inspired by the CMLS framework could be to alter the level of selection. Waring et al. argue this can be done by manipulating the balance of costs & benefits of unsustainable selfish behavior and sustainable cooperative behavior. If there is more to gain for the group and cooperation is less costly for the individual, selection will be dominant at the level of the group. Therefore, more (sustainable) cooperative behavior will be selected for eventually. An example of this could be deposits paid for packaging. It might be in the interest of the individual inhabitant of a city to throw plastic bottles away wherever they want to. This will lead to pollution, bad hygiene and less tourism in the city, which is not in the interest of the group. When deposit is paid back to civilians that turn in their bottles, the costs to the individual are reduced through a monetary incentive. This can cause the city to be the dominant level of selection, resulting in a selection process for cooperative sustainable behavior of its inhabitants.

Waring et al. argue that the level of selection can also be altered by increasing trait variation between groups, while the trait variation within these groups is reduced. This should result in selection being more dominant at the level of the group. Therefore, Waring et al. (2015) argue that “sustainability interventions that manage the distribution of the sustainability-relevant traits across levels may help facilitate stronger selection on the desired level” (p. 9). In the Fiji case, this would be caused by the village chiefs enforcing certain rules of behavior, so that all individual foragers within a village chiefdom will display the same sustainability-relevant behavior. This way, the more sustainable group would outcompete groups with less effective sustainability-relevant behavior more quickly. If both groups consisted of individual foragers with diverse sustainability relevant behavior, it is not likely for sustainable cooperative practices to be selected for at a group level.

4.5 Evaluating the framework

Waring et al. have shown that the CMLS might be applied to specific cases in order to try and understand cases of social-ecological change and the emergence of cooperative sustainable behavior. They have also suggested ways in which this new framework could help design effective solutions to sustainability issues in the present. In this section I will critically evaluate the framework, and discuss whether it can realistically be expected to play a role in solving sustainability issues.

As seen in the Fiji example, it does seem that a CMLS approach provides new insights into the emergence of cooperative sustainable behavior. It shows how different interests at different levels of selection interact and how the sustainable cooperative behavior likely emerged due to selection being dominant at the level of the group, as well as how it disappeared when the group was no longer the dominant level of selection. This description does not necessarily contradict the historical facts. It is however difficult to determine the dominant level of selection with certainty using the vague guidelines proposed by Waring et al. (2015), when they state that:

> Group selection will tend to be stronger than individual selection when (1) a greater fraction of total trait variation occurs between groups than between individuals, (2) the relative benefits to the group are greater, and (3) the costs to cooperative individuals are lesser. (p. 4)

These criteria are quite vague, and they are hard to quantify or measure objectively. At what point is the trait variation between groups large enough to make group selection dominant? How does one measure and compare costs and benefits of groups and individuals? How does the cost benefit ratio interact with the degree to which trait variation occurs between groups? Issues like these arise when trying to determine the dominant level of selection. This makes the CMLS explanation of marine tenure institutions in Fiji a hypothesis, one that is not yet able to be proven conclusively. When analysing historical cases this need not be a problem; making a general estimation of the dominant level of selection might still provide new insights and explain developments that would appear mysterious otherwise. It does however become more difficult to design effective solutions to present day sustainability issues. Aiming policy at the dominant level of selection, or attempting to change the dominant level of selection through policy requires reliable data on what the dominant level of selection is, as well as an understanding under exactly what circumstances it is likely to change. In absence of these data, efforts to solve sustainability issues might fail to alter the balance of costs and benefits between groups and individuals enough to change the level of selection. It is also possible for instance for policies to vastly overshoot the required reduction in individual costs for cooperative behavior, resulting in a waste of resources or wealth that would have been better allocated elsewhere. This can hardly be considered the way of producing *effective* solutions to sustainability issues that Waring et al. claim it to be.

Another issue with the framework is that Waring et al. tend consider cooperative behavior as synonymous to sustainable behavior. But this is not the case. As mentioned by Snyder (2020), sustainable behavior is rarely beneficial to the group. To the contrary, groups that behave unsustainably outcompete the more sustainable groups in the short-term. If this is the case, making the group level the dominant level of selection would only serve to increase selection for unsustainability. This can in fact be observed in one of the other case narratives presented by Waring et al.. Evaluating the history of national environmental policy in Bhutan, Waring et al. (2015) come to the conclusion that "competition between ethnic communities and villages fuelled warfare that likely led to resource extraction" (p. 6). This is the polar opposite to the Fiji case, where warfare between villages was claimed to result in selection for more sustainable resource extraction. It is not just the dominant level of selection that determines the emergence of sustainable behavior, it requires circumstances in which sustainable behavior is actually beneficial to the group as well. On Fiji, the harshness and unpredictability of the environment and the fact the villages were more easily defended than attacked resulted in greater benefits to sustainable resource use. In the absence of those circumstances, selection at the group level selected for unsustainable resources use in Bhutan. In later research Waring, Goff & Smaldino (2017) reached similar conclusions. Institutions enforcing sustainable resource use only emerge under harsh and unpredictable circumstances, in which resources are scarce. If this is not the case, unsustainable behavior will be selected for. This drastically limits the number of cases Waring et al.'s proposed solutions may apply to. Furthermore, adding these extra conditional circumstances to their model of the emergence sustainable behavior has negative consequences for the generalizability of causal patterns in social-ecological context in their framework.

Even if solutions to sustainability issues can be selected for at the group level under certain circumstances of scarcity, it can only do so on a local scale. If a sustainability issue takes place on a worldwide scale, then it is no longer possible to turn to a higher level and render it the dominant level of selection. There is currently no higher level than the level of human life on earth, nor is there competition between the inhabitants of earth and other lifeforms in the galaxy. It is simply impossible for a process of selection to act on a population of one. Therefore, selection can not take place, let alone be dominant at a planetary level. This poses a problem, because the most pressing sustainability issues like climate change or plastic pollution occur on planetary scale. As Zefferman (2018) argues, no process of cultural group selection can lead to a solution for the sustainability dilemma that is climate change. The benefits of cutting back greenhouse gas emissions apply to all parties, but the costs only apply to those that actually cut back on greenhouse gas emissions. Competition at the level of individual countries would eventually lead to selection for free riding behavior and selfish strategies. Selection at a higher planetary level is not possible, leaving the sustainability dilemma unresolved. This leaves the solutions proposed by Waring et al. unable to solve the most pressing sustainability issues.

This problem is enhanced by the fact that our current world is becoming extremely globalised. Almost every sustainability issue that occurs on a local scale is no also influenced by processes at a planetary scale. Due to our global market economy, there is always a form of competition on a global scale. Local sustainability issues regarding resource use might emerge due to competition on the global market economy, just as happened in the Fiji example. Furthermore, the most environmentally impactful groups are multinationals. It is exactly this type of group that is not sensitive to sustainability issues at a local scale. Because multi-nationals are not tied down to a certain area, they are able to relocate whenever a source of resources is depleted on a local scale. This selects for multi-nationals that extract a maximum amount of resources, as they have little to gain from sustainable practices.

This leaves very few situations in which the solutions the framework offers can actually be effective. In later research (Waring, Goff & Smaldino, 2017) identify one realistic scenario in which selection for sustainable behavior is likely to be selected for at a worldwide scale. This is however not a very desirable scenario. In order to make groups compete for longevity and sustainability, harsh environments and resource scarcity would be required. The scenario in which these requirements are met is in a global resource collapse. Now, this might actually become the case, for if the most pressing sustainability issues are not solved, this is exactly where we will end up. This does however call the usefulness of the CMLS frame by Waring et al. (2015) in question, because scenarios like this are exactly what the discipline of Sustainability Science is generally trying to prevent. From a CMLS perspective, solutions to pressing worldwide sustainability issues might only be found after the sustainability issues get out of hand. This would have dire consequences for human well-being.

In sum, then, the framework by Waring et al. allows for a new way to think about past cases of emergence of sustainable or unsustainable behavior. However, their approach would need to be much more refined in order to accurately determine the level at which selection takes place. It also needs to be expanded to include additional types of circumstances that encourage selection for sustainable behavior, if this is possible without harming the frameworks ability to generalize about causal relations in social-ecological contexts. The framework is mainly lacking in its ability to help design effective solutions to sustainability issues. If capable of being applied accurately, the solutions suggested by Waring et al. (2015) would only work in very specific cases wherein the environment is harsh and unpredictable, and resources are scarce. Secondly, the solutions would not work for sustainability issues that occur at a planetary scale. This problem is exacerbated by the fact that globalization has led to a decrease of sustainability issues that exist solely on a local scale, making most issues (in)directly take place partly on a planetary scale. In our current globalized world, the most likely scenario in which sustainable behavior is selected for is in case of global resource collapse, which is exactly the type of scenario a framework for Sustainability Science should be able to prevent from occurring.

This is not to say the framework by Waring et al. is entirely useless. An understanding of why the solutions the framework suggests are unlikely to work from a CMLS perspective is in itself valuable knowledge for the design of sustainability solutions. A selection process is unlikely to solve world wide sustainability issues, so attention can be directed elsewhere. Furthermore, an understanding of the role of conflicting interests between individuals and groups might still prove useful in designing effective solutions. The CMLS framework, if refined, could contribute to new insights regarding sustainability issues. It is the suggestion by Waring et al. (2015) that solutions can be found through a process of selection that is misguided.

Conclusion

The concept of Cultural Multi-Level Selection is, to some extent, able to contribute to the discipline of Sustainability Science. It is not able to help determine desirability of sustaining specific social-ecological states, but it can provide new insights describing the emergence and sustainability of social-ecological states. CMLS provides an explanation for the evolution of cooperative behavior and large-scale cooperation in humans, which other evolutionary approaches struggle to provide. Snyder (2020) and Ellis et al. (2018) rightfully claim that the regular occurrence of human encounters with sustainability issues throughout history are likely ultimately caused by an evolutionary feedback loop in a process of CMLS. However, both authors focus on specific elements in this feedback loop (i.e., energy extraction in Snyder & ecosystem engineering in Waring et al.), which creates problems and places limitations on their explanations. Instead, focussing on a less problematic feedback loop between population size and the rate of cultural evolution could suffice, because both ecosystem engineering & energy extraction strongly correlate with the rate of cultural evolution. Therefore, I conclude that CMLS is can help explain the emergence of sustainability issues throughout human history. Waring et al. propose a framework to help organize facts about social-ecological change and the emergence of sustainable behavior at multiple organizational levels consistently in a generalizable way, and ultimately help design effective solutions to sustainability issues. The framework does provide a way to organize these facts and provide new insights, but it can not be applied accurately. It is also far from generalizable in its current form. The solutions to sustainability issues Waring et al propose are very unlikely to succeed due to difficulty in determining the dominant level of selection, cooperative behavior only equating to sustainable behavior under specific circumstances, and the impossibility of selection processes taking place at a planetary level. This leaves the framework by Waring et al. unable to provide solutions to pressing sustainability issues. Taking all its limitations into account, CMLS could potentially provide some valuable contributions to Sustainability Science. Its potential use mainly lies in explaining why sustainability issues arise among humans and in modelling conflicting interests between levels of organization. In order to do this effectively though, its methods would need to be more precise than those proposed by Waring et al.. CMLS is however not capable of reliably providing solutions to sustainability issues, because solutions are unlikely to evolve through a process of selection. Therefore knowledge from CMLS approaches should be taken into account, but it should not be guiding in the design of solutions to sustainability issues.

Literature

Ayres, I., Raseman, S., & Shih, A. (2013). Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. *The Journal of Law, Economics, and Organization, 29(5),* 992 1022.

Bowles, S., & Gintis, H. (2003). *Origins of human cooperation. Genetic and cultural evolution of cooperation*, 2003, 429-43.

Boyd, R., & Richerson, P. J. (2006). Solving the puzzle of human cooperation. *Evolution and culture*, 105-132.

Boyd, R., Richerson, P. J., & Henrich, J. (2011). The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences*, *108*(Supplement 2), 10918-10925.

Brown, J. H., Marquet, P. A., & Taper, M. L. (1993). Evolution of body size: consequences of an energetic definition of fitness. *The American Naturalist, 142(4)*, 573-584.

Darwin, C. (2016). *On the origin of species*, 1859.

Darwin, C. (1871). *The descent of man*. New York: D. Appleton.

Dawkins, Richard (1976). *The Selfish Gene*. Oxford University Press, USA

Devall, B., & Sessions, G. (1985). *Deep ecology*. Pojman.

Ellis, E. C. (2015). Ecology in an anthropogenic biosphere. *Ecological Monographs, 85(3),* 287-331.

Ellis, E. C., Magliocca, N. R., Stevens, C. J., & Fuller, D. Q. (2018). Evolving the Anthropocene: linking multi-level selection with long-term social ecological change. *Sustainability Science, 13(1)*, 119-128.

Fowke, R., & Prasad, D. K. (1996). Sustainable development, cities and local government: Dilemmas and definitions. *Australian Planner*, *33*(2), 61-66.

Fuller, D. Q., Denham, T., Arroyo-Kalin, M., Lucas, L., Stevens, C. J., Qin, L., ... & Purugganan, M. D. (2014). Convergent evolution and parallelism in plant domestication revealed by an expanding archaeological record. *Proceedings of the National Academy of Sciences, 111(17),* 6147-6152.

Garland Jr, T., & Carter, P. A. (1994). Evolutionary physiology. *Annual review of physiology, 56(1)*, 579-621.

Gowdy, J., & Krall, L. (2013). The ultrasocial origin of the Anthropocene. *Ecological Economics*, *95*, 137-147.

Gupta, J. (2007). The multi-level governance challenge of climate change. *Environmental Sciences, 4:3*, 131-137.

Hamilton, W. D. (1963). The evolution of altruistic behavior. *The American Naturalist*, *97*(896), 354-356.

Hamilton, W. D., 1964. The genetical evolution of social behaviour I and II. *Journal of theoretical biology, 7*(1), 1–52.

Harris, D. R., & Fuller, D. Q. (2014). Agriculture: definition and overview. *Encyclopedia of global archaeology*, 104-113.

Henrich, J. 2004. Cultural group selection, coevolutionary processes and large scale cooperation. *Journal of Economic Behavior & Organization 53(1)*, 3-35.

Henrich, J. (2004). Demography and cultural evolution: how adaptive cultural processes can produce maladaptive losses—the Tasmanian case. *American antiquity*, *69*(2), 197-214.

Henrich, J. (2017). *The secret of our success: How culture is driving human evolution, domesticating our species, and making us smarter*. Princeton University Press.

Henrich, J., & Gil-White, F. J. (2001). The evolution of prestige: Freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and human behavior*, *22*(3), 165-196.

Hill, K. R., Wood, B. M., Baggio, J., Hurtado, A. M., & Boyd, R. T. (2014). Hunter-gatherer inter-band interaction rates: Implications for cumulative culture. *PloS one*, *9*(7)..

Kates, R. W. (2011). What kind of a science is sustainability science? *Proceedings of the National Academy of Sciences*, *108*(49), 19449-19450.

Lewontin, R. C. 1970. The units of selection. *Annual Review of Ecology and Systematics 1*, 1–18

Lotka, A. J. (1922). Contribution to the energetics of evolution. *Proceedings of the National academy of Sciences of the United States of America*, *8*(6), 147.

Matson, P. A., Parton, W. J., Power, A. G., & Swift, M. J. (1997). Agricultural intensification and ecosystem properties. *Science, 277(5325),* 504-509.

McDonald, M. M., Navarrete, C. D., & Van Vugt, M. (2012). Evolution and the psychology of intergroup conflict: The male warrior hypothesis. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1589), 670-679.

Mesoudi, A. 2011. *Cultural evolution: how Darwinian theory can explain human culture and synthesize the social sciences.* University of Chicago Press, Chicago, Illinois, USA.

Mesoudi, A., A. Whiten, and K. N. Laland. 2006. Towards a unified science of cultural evolution. *Behavioral and Brain Sciences 29(4)*, 329-347.

Kline, M. A., Waring, T. M., & Salerno, J. (2018). Designing cultural multilevel selection research for sustainability science. *Sustainability Science, 13*(1), 9-19.

Perreault, C. (2012). The Pace of Cultural Evolution. *PLoS ONE, 7*(9), Petersen, J. E., Shunturov, V., Janda, K., Platt, G., & Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real time visual feedback and incentives. *International Journal of Sustainability in Higher Education.*

Pianka, E. R. (1970). On r-and K-selection. *The american naturalist, 104(940),* 592-597.

Ponting, C. (2007). *A new green history of the world: the environment and the collapse of great civilizations*. Random House.

Powell, A., Shennan, S., & Thomas, M. G. (2009). Late Pleistocene demography and the appearance of modern human behavior. *Science*, *324*(5932), 1298 1301.

Richerson, P.J., Boyd, R., 2005. *Not by Genes Alone: How Culture Transformed Human Evolution.* University of Chicago Press, Chicago.

Schill, C., Wijermans, N., Schlüter, M., & Lindahl, T. (2016). cooperation is not enough—exploring social-ecological micro-foundations for sustainable common-pool resource use. *PloS one*, *11*(8).

Scott-Phillips, T. C., Dickins, T. E., & West, S. A. (2011). Evolutionary theory and the ultimate proximate distinction in the human behavioral sciences. *Perspectives on Psychological Science*, *6*(1), 38-47.

Smith, B. D. (2007). Niche construction and the behavioral context of plant and animal domestication. *Evolutionary anthropology: Issues, news, and reviews: Issues, News,and Reviews, 16(5),* 188-199.

Snyder, B. F. (2020). The genetic and cultural evolution of unsustainability. *Sustainability Science, 15(4),* 1087-1099.

Strassmann, J. E., Page, R. E., Robinson, G. E., & Seeley, T. D. (2011). Kin selection and eusociality. *Nature*, *471*(7339), E5-E6.

Velders, G. J., Andersen, S. O., Daniel, J. S., Fahey, D. W., & McFarland, M. (2007). The importance of the Montreal Protocol in protecting climate. *Proceedings of the National Academy of Sciences*, *104*(12), 4814 4819.

Vlerick, M. (2016). Explaining universal social institutions: A game-theoretic approach. *Topoi*, *35*(1), 291-300.

Van Vugt, M., Griskevicius, V., & Schultz, P. W. (2014). Naturally green: Harnessing stone age psychological biases to foster environmental behavior. *Social Issues and Policy Review*, *8*(1), 1-32.

Waring, T. M., Kline Ann, M., Brooks, J. S., Goff, S. H., Gowdy, J., Janssen, M. A., ... & Jacquet, J. (2015). A multilevel evolutionary framework for sustainability analysis. *Ecology and Society, 20*(2).

Waring, T. M., Goff, S. H., & Smaldino, P. E. (2017). The coevolution of economic institutions and sustainable consumption via cultural group selection. *Ecological economics, 131,* 524-532.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Gałuszka, A., ... & Wolfe, A. P. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science, 351(6269)*.

Wilkinson, G. S. (1984). Reciprocal food sharing in the vampire bat. *Nature*, *308*(5955), 181-184.

Zefferman, M. R. (2018). Cultural multilevel selection suggests neither large or small cooperative agreements are likely to solve climate change without changing the game. *Sustainability Science*, *13*(1), 109-118.

Summary

In this thesis I evaluate whether the evolutionary school of thought of Cultural Multi-Level Selection (CMLS) can yield new insights to the discipline of Sustainability Science. Ellis et al. (2018) and Snyder (2020) propose it can explain the emergence of sustainability issues through human evolutionary history and Waring et al. (2015) propose a framework through which solutions can be found to current sustainability issues. I argue that Ellis et al. and Snyder are correct, but their approaches could be enhanced by putting more emphasis on the process of cultural evolution. I argue the framework by Waring et al. lacks accuracy to be applied well, falsely equates group-beneficial behavior with sustainable behavior and isn't applicable to sustainability issues on a worldwide scale.