Sources of Innovation in the Brazilian Amazon Rainforest

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Abstract:

The Amazon Rainforest, known as ‘the lungs of the Earth,’ has been under threat for decades. There has been a domino effect of global insecurities caused by the extraction of resources through human interventions, including industrial activity and large-scale agriculture. With new data and research showing the rising levels of environmental degradation, the international community has joined together under a unified goal to combat environmental insecurity. From locals and governments to the private and public sectors, stakeholders across industries have pledged to devote their time and resources to creating more climate-friendly regulations, innovation, and action plans. A congruent part of creating a more sustainable world comes from scientific research and technological advancements. While innovation is generally seen to be tied to economic patterns, it can also be used for the objective of human growth. Under the latter objective, innovation has the potential to play an intrinsic role in resolving environmental insecurity. However, the effects of innovation in the shape of emerging technologies will vary depending on how an actor understands the meaning of innovation.

As sources of innovation continue to evolve, there is a need to investigate the long- and short-term impacts of innovation on sustainability and, more importantly, understand the cause and effects of innovation through the perspective of various levels of stakeholders. As such, this dissertation seeks to explore the relationship between innovation and sustainable practices. The objective of this dissertation is to explain how sources of innovation shape sustainable practices as a means to combat environmental insecurity. Using the case of Artificial Intelligence (AI), this dissertation inquires about the research question: 'what are the impacts of innovation in terms of sustainability? More specifically, how have emerging technologies altered sustainable practices in relation to deforestation in the Brazilian Amazon Rainforest?

In a comparative, exploratory case study, the analysis investigates the case of Artificial Intelligence through a Social Construction of Technology (SCOT) framework. The first part aims to understand the evolution of Artificial Intelligence and how its meaning has changed over time, while the second part looks at the case of AI implemented into the development projects to combat deforestation launched by the Amazon Institute of People and the Environment’s (Imazon). Expanding on the evidence found in the analysis, the discussion will discuss a second, broader question: what is considered "effectiveness" in terms of sustainable development practices? Looking at AI through the lens of the environment and the SCOT theory

provides a useful angle for understanding the implementation of innovation and the misaligned motives of actors. As such, the measure of "effectiveness" related to the implementation of sustainable technology is subjective. Furthermore, technology operations and development aimed at improving sustainability continue to prioritize economic outputs. The dissertation findings explore how effective change towards sustainability does necessarily work just through cross-collaboration. Rather, there needs to be more insight from minority groups most affected by environmental insecurity. As such, the dissertation expands on the need for a paradigm shift away from the capitalist system that is currently ruling the world.

1. Introduction

In the world we live in today, environmental degradation has become a global threat. The consequences of socio-economical, institutional, and technological human activities have led to the rising climate crisis that threatens the future of our planet. The overpowering capitalistic paradigm that society has followed since the Industrial Revolution is impacting the natural balance and has arguably become the most significant contributor to security risks for both humans and the natural world (Folk, 2021). Anthropogenic practices and norms, including industrial development, extraction of natural resources, and global consumption, have created many challenges, from the emission of greenhouse gases (GHG) to the depletion of food and water sources. The data and research that have come out during the twenty-first century have only further outlined the severity of the effects of environmental insecurity. The scientific community has known about some of these dangers for generations; the first paper to identify carbon dioxide as a greenhouse gas was published in 1896 by Svante Arrhenius (Rodhe et al., 1997), and oil companies well understood the effects of burning fossil fuels on the environment from at least the 1970s (Hall, 2005). Despite this knowledge, it is only recently (due to political pressure? Civil society activism? The obvious nature of the threat or the fact that the world is now beginning to see the consequences of inaction, or maybe all of the above?) that humanity has started to take the challenge more seriously.

With the gravity of the climate crisis only getting worse, our society has pledged to embark on a journey to create a more sustainable future. Governments across the world have spent the last two decades establishing treaties, policies, and sustainable frameworks as a means to combat the growing concerns of not just the climate crisis but any security threats towards individual-, community-, or eco-centric referent points. Actors across sectors have begun to collaborate under a unified goal of fighting for our planet. Despite the unified front, phasing society out of its current economic stature toward a more sustainable one will not be easy. Both the public and private sectors will play a critical role in designing and managing strategies compatible with a low-carbon economy, especially in countries that are most susceptible to climate challenges. As eloquently put by Sugerman and McDougall (2021): “in order to implement a just and equitable transition to a low-carbon economy, countries around the world will need to re-allocate labour resources from carbon-intensive industries to cleaner alternatives in order to preserve economic opportunities and mitigate downstream community impacts.”

The Amazon Rainforest, a global common, is one of the most important ecosystems on Earth. Both the largest rainforest and river basin in the world, the Amazon covers over 6,000,000 square kilometres of South America, making up roughly 40% of Brazilian territory (Britannica, 2019). The widespread South American Rainforest is home to over 20% of Earth's biodiversity, containing millions of species from insects, mammals, trees, and amphibians to other types of living organisms such as fungi and bacteria (CNN, 2013). The importance of the rainforest comes from not only its rich biodiversity but also the role that the Amazon plays in carbon capturing. Natural carbon capturing occurs through a process known as photosynthesis, in which trees absorb and remove billions of tons of carbon dioxide from the atmosphere, in turn helping to regulate global temperatures (NASA, 2019). As the largest tropical rainforest in the world, the Amazon Rainforest is nicknamed the 'lungs of the planet'. It is known for its natural ability to regulate Earth's carbon and oxygen cycles (BBC, 2013). However, the role of the Amazon in the international system has shifted from natural carbon absorber to carbon emitter.

Since the 1960s, global trade patterns have driven unethical practices to expand the agriculture sector (Burrow, 2019). Unsustainable farming practices due to market demand for soy and cattle, paired with low-cost productions and inadequate land governance, have led to devastating repercussions for the rainforest. The increased clearing of the rainforest has not only constrained the Amazon from combating CO2 emissions, but adversely, it has become the cause of CO2 emission (Carrington, 2021). Deforestation and other land clearing practices are a few of the many negative environmental insecurities affecting the Amazon. Environmental degradation has led to further threats, including the loss of biodiversity and habitat, pollution, and the depletion of resources. Furthermore, outside of nature-rooted threats, the economic management of the Amazon has caused many societal threats, including to public health and economic stability, and has contributed to geopolitical tensions and transnational crime. Rich biomes such as the Amazon are reaching their tipping point. Now more than ever, there is a need for action against deforestation, environmental degradation, and all other unsustainable anthropogenic practices.

Today, the world is feeling the weight of the damages caused by an interwoven list of practices and norms driven by a capitalistic economy. Some people are feeling the consequences of these damages more than others. It will take a paradigm shift, one that

prioritizes the environment in order to begin the process of healing our Earth. The sustainable journey we are going to embark on will take the collaboration of the masses, from governments and corporations down to communities and individuals. The innovation and technology sector will be an integral part of the transition process. Innovation consists of toolsfor human and economic development, making sources of innovation a critical part of the solution to creating a greener future. It is due to this that there is a need for a further understanding of the relationship innovation has with sustainable development.

This research aims to consider the impacts that sources of innovation have on solutions to combating environmental insecurity. In order to achieve this, the research uses exploratory case studies looking at Artificial Intelligence (AI) implemented in sustainable practices aimed at mitigating deforestation in the Brazilian Amazon Rainforest. Narrowing the focus to a single emerging technology, the papers seek to explain a more significant phenomenon that questions the impacts that sources of emerging innovation have on environmental insecurity. Using the Social Construction of Technology (SCOT) as the analytical framework, this dissertation aims to take a new perspective on understanding the relationship between innovation and sustainable development practices. To start, there will be a Literature Review that will be split into two parts. Part One explains the theoretical security framework that is being argued in the paper. This part gives a contextual understanding of the evolution of security leading up to environmental security, which is the theoretical security framework under which this topic will be analysed. Part Two will explain the resolutions that the global community set into action to combat environmental insecurity. This part will further describe innovation as a vital component in not only human development but also sustainable development. Next there will be an overview of deforestation as a global threat, and more specifically threat to the Amazon. It will then describe two influential sources of innovation (roads and satellites) used to combat deforestation in the Amazon. The next section of the paper will explain what the research question is, the design of the research, methodology, and framework that will be used to analyse the data as well as the limitations of the analysis. The research itself will consider the case of Artificial Intelligence, looking at the evolution of the technology and a case where AI has been implemented into projects against deforestation in the Amazon. The final section will discuss the findings and results as well as expand the research further to debate the challenges posed by misaligned measures of effectiveness in sustainable development practices.

2. Literature Review Part One: Theoretical Security Framework

Like many unorthodox theories, environmental security is a contested topic in the field of security. It is argued that while environmental insecurity is a global concern, it is not considered a priority threat that drives decision-making in an international system. In order to understand the importance of environmental security within critical security studies, the first part of the literature review will explain what security is and how the concept has evolved over time. This first part of the Literature Review seeks to explain one, how the semantics of the term 'security' influence individual political outlooks and two, the historical evolution of critical security studies. This section will discuss traditional theories (considered the dominant school of thought), the development of alternative security theories (i.e. human security), and conclude with an overview of environmental security, which is the theoretical security framework that this paper will be working under. The overview of environmental security seeks to explain the link between the environment and security and why it must be considered a global threat. It will be outlined how, although unorthodox and contested, environmental security, couched within the school of critical security studies, is a legitimate school of thought worthy of attention and pursuit.

2.1 History of Security Studies

There are four fundamental questions that scholars, politicians, and pragmatics have pondered when trying to understand the meaning of security: what is security, who/what is being secured, what types of securitizations are there, and how can security be achieved (Williams and McDonald, 2018). The challenges that come when trying to answer these questions have led to countless disputes on the establishment, education, and institutionalization associated with security. Security is a concept that changes based on the time period, space, and actors involved. It is considered a 'derivative concept,' in which one's understanding of the term also shapes that person's political and philosophical outlook of the world (Booth, 1997, pp.. 104-119). As security plays a vital role in international relations, the epistemology of 'security' will intrinsically have unavoidable political effects.

2.1.1 Traditional Security: Realism

Semantically, the word security has been used throughout history. However, as a subject of academic inquiry, it is a relatively recent term. It is often argued that the contemporary field of

security studies gained popularity following World War II (Booth, 1997; Buzan and Hansen, 2009). Heavily influenced by European and American ideas, Western governments started implementing new standards in the 1960s and 1970s based on the conceptual ideas, innovations, research, and proposals that academic institutions set out. These new standards would then influence the bureaucratic decision-making process of military strategies, foreign policies, security policies, and the overall structural framework for various political issues (Williams and McDonald, 2018).

As security studies started to kick off during the Cold War, 'traditional security' became the dominant approach influencing politics and international relations. Traditional securities' fundamental principle is that the state is the referent object. With the core of the theory being the preservation and protection of sovereignty, all the other questions surrounding security are tailored to that referent point. The primary school of thought in security studies, traditional security theory, believes in hard power solutions when implementing securitization strategies. Hard power solutions use military and economic means to mitigate and defend against threats. Furthermore, traditional solutions use objective and scientific knowledge as tools to protect the status quo in an international system. This means that science is typically only used to implement security policies that maintain the status quo, a status in which hegemonic states keep a position of power while also preventing radical/revolutionary changes (Williams and McDonald, 2018). Realism is considered the umbrella term in the traditional school of thought, covering a diverse range of theories. Despite the vast interpretations, the core principles of realism stay the same. These principles are understood through four propositions: state-centrism, anarchy, egoism, and power politics (Donnelly, 2000). State-centric by nature, realist theories are often used to describe the Cold War era. The Cold War was a proxy war that started in the 1960s and portrayed global power dynamics between two hegemonic powers: the United States and the Soviet Union. Because realist security believes that the state is the referent object, realist theorists also believe that the protection of the state is derived from hegemony within the international system. It is due to this that competition for power is at the heart of realism (Donnelly, 2000). During the Cold War, the United States and the Soviet Union were engaged in a battle for hegemony. Both nations were working for their own self-benefit, seeking to expand their ideological and geopolitical influence across the globe. By acting in accordance with security through a realist lens, the two countries believed that being the higher controlling

entity would ensure global power and state security. In turn, the power play between the United States and USSR shaped the international political landscape.

2.1.2 Critical Security Theories

In the 1990s, following the Cold War era, came a shift in the concept of 'security.' Attempts to rethink conventional understandings of security led to a new wave of thought known as critical security theories. Radical literature and debates of the time were introducing a new forum for discussion. For the first time, the dominant theoretical approach influencing the bureaucratic system was challenged. Critical security studies believed that there could be a deepening in the way that security was approached; for example, this included approaches in which the state was not necessarily the only referent object (Peoples and Vaughan-Williams, 2021). Critiques, including Hansen's idea of the 'Security Dilemma,' believed that the securitization of one state adversely came at the cost of another state's security (Hansen, 2000). Ken Booth, a precursor of critical studies, argued that the discourse of the term security changed the concept (Booth, 2005). He believed security was culturally bound because it was influenced by both philosophical and political opinions. Booth explains that when security is considered a derivative concept, it is because it is an 'instrumental value' in which securitization is not the end goal but, rather, an ongoing process (Booth, 2005). Traditional security views the security of the state as the endpoint. In contrast, if it is considered a process, negotiations around security could open the door to other possibilities of restructuring. There could be an opportunity for coexistence between different political outlooks that don't intrinsically end with the deprivation of certain people's lives (Alker, 2005, pp. 189-213). The critiques that arose during the 1990s led to the establishment of alternative schools of thought, including the Aberystwyth School, Copenhagen School, Frankfurt School, and Paris School. Critical scholars allowed for the broadening of security, opening the conversation to inclusivity of cross-disciplines (Beier, Grayson, and Mutimer, 2013).

2.1.3 Human Security

Outside of critiques surrounding the epistemological understanding of security, another factor that influenced the broadening of the concept was a shift in threats. States were not simply going to war against other states anymore. New, more complex threats that transcended national borders began to arise; threats including underdevelopment, disease, poverty, transnational

crime, environmental degradation, and climate (UNDP, 1994). The relationship and activities occurring between states started to become multifaceted, with the same holding true for the threats they faced. Globalization brought with it a rapid change to the world. This change required a more comprehensive understanding of securitization and the need for a framework that presaged new theories which would effectively evaluate the international system. In 1994, the UN's Human Development Report established the idea of 'human security,' an umbrella term that undertook a more progressive view on how to target security challenges. Human security is characterized by seven different dimensions of security: economic, food, health, personal, community, political, and environmental (Tadjbakhsh, 2007, p. 15).

The establishment of the UN's understanding of human security was the first assertion to create a security framework that understood the interwoven components of security threats and aimed to develop a holistic approach to mitigate those threats. Arguably the central part of human security, like other critical schools of thought, was that the referent object shifted from the state to the individual. It was the first formally written doctrine to express security as a concern relevant to people everywhere (Timothy, 2004). Veering away from the traditional state-centric notions of military and territorial security, human security focused on the broader protection of the individual. The threats reported by the UNDP widened from local to global affairs. The categorization made by the UNDP included: "unchecked population growth, disparities in economic opportunities, excessive international migration, environmental degradation, drug production and trafficking, and international terrorism (UNDP, 1994, p. 34). Human security's all-encompassing conceptualization was an attempt to encapsulate the issues that needed to be targeted by political agendas as a means to change the international system (Scott and Thapa, 2015). Despite its inclusive and all-encompassing nature, there are those who believe that Human Security is a concept that is spread too thin to the point to which it provides no direction for any bureaucratical change (Thomas and Tow, 2002). The lack of clarity poses a challenge for governments, who must decide which threats to prioritize while working with limited resources and funds. As Liotta argues, the broadening of security will cause a Boomerang Effect in which "security becomes so wide it becomes all things to all people—or nothing to no one (Liotta, 2002)." While the critiques on human securities' ambiguity are acknowledged, the unbound nature of its definition can also be considered a strength. The fact that the UN developed a concept of security that prioritizes individual safety concerns has

allowed for the conditions to be set to make development possible. It has laid the groundwork for systematic change. Human security has built a connection between humans, the environment, and traditional threats. Human security brings society one step closer to linking the direct and indirect linkages that security has with matters of the environment.

2.2 Environmental Security

Environmental Security is a theoretical framework that analyzes security through the lens of the environment (Franke, 2004; Barnett, 2001). In an academic sphere, environmental security investigates the drivers and consequences of a variety of issues from an ecological perspective (Detraz, 2009). The root of the concept can be traced back to the mobilization of the environmental movement in the 1960s and 1970s (Collins, 2014; Barnett, 2001). Environmentalists were the first to recognize the link between environmental, social, economic, and military threats. Significant pieces of literature, including Silent Spring by Rachel Carson (1962), helped increase environmental consciousness across the world. The growing talks around environmentalism led to the spreading of awareness across the global north to crucial issues regarding the environment, especially issues that were occurring in developing countries. During this time, environmental threats were still not considered security threats; however, over the next two decades, disastrous environmental occurrences began to shed light upon the linkage between the environment and security to the international community. One example of this was in 1967, in the war between Israel and Jordan. The tensions between the two countries over water security showed how resource conflict could contribute to more traditional threats. Another example could be seen during the oil crises of the 1970s, which led to a change in the western world's national security structure due to its dependency on foreign oils. As the world globalized, the threats caused by environmental degradation began affecting actors across boundaries. The direct and indirect threats caused by environmental issues, in turn, led to the Stockholm Conference, considered by some as the introduction of environmental risks to the sphere of international politics (Floyd and Matthew, 2013, p. 139). For the first time, analysts and policymakers were considering ecological issues in the language of security.

Environmental security began to encompass a vast array of global threats. Some of those threats included rising levels of GHG emissions, depletion of the ozone layer, natural resource depletion, destruction of biomes, pollution, deforestation, and waste management. In recent years, the concept has expanded to a broad array of interpretations, causing disputes amongst

theorists as to what exactly environmental security is. Within critical security studies, environmental security contests the dominant opinion that the state is the referent object; this means that instead, the referent object can change from a state-, human-, or biosphere-orientation depending on who is being asked (Floyd and Matthew, 2013 p. 21). The school of thought has come to encompass a variety of issues including energy security, climate security, ecological security, conflict, and peacebuilding, etc. While the field continues to grow in many different directions, the principal objectives remain the same: "to trace the evolution of security discourses, consider securitization of the environment and natural resources, and assess new conceptions of environmental security in the context of global change"(Scott and Thapa, 2015). The principles of environmental security bring a new perspective on pressing security challenges. Those security challenges, especially in a globalized system, must remain a top concern within the policymaking world.

There is an inherent relationship between the environment and security. Whether it is natural disasters or anthropogenic practices, environmental insecurity has a direct and indirect impact on political disputes, violent conflicts, and the security of the international system. Traditional security theories are too narrow-minded; the issues prioritized by traditional security studies are no longer valid as the singular threats shaping the world. Environmental security is a new way of thinking that can allow for the reshaping of conduct on the international playing field (Floyd and Matthew, 2013). Despite its ambiguous nature, environmental security studies encompass an interrelated web of threats that coincide with a globalized world. It is this transition to a more inclusive way of thinking that will allow for a new movement, one in which the global system makes decisions based on not only the state but also the individual and the biosphere. By changing the prioritization of threats, international decision-makers can reorient their goals towards new outcomes that do not come at the cost of the environment.

3. Literature Review Part Two: Steps to Solving the Insecurity

This section will give some background as to the ripple effects that occurred once the world began to acknowledge environmental security as a critical threat. To begin with, there will be an explanation of the different global treaties and actions taken over the years as means to start addressing environmental issues. This section will explain the introduction of sustainable development and how the world is trying to implement more sustainable practices into the

international system. To further expand on global responses, the next section will elaborate on what innovation is and how it is considered a tool for sustainable development. To conclude, the focus will narrow to explaining deforestation, a significant security threat in the Amazon Rainforest and how previous technological advancements have affected the Brazilian Amazonian local and global actors.

3.1 Awareness of Environmental Insecurity in the International Sphere

The drastic impacts of environmental insecurity that arose in the second half of the 20th century could no longer be ignored. Scholars, scientists, politicians, and practitioners began trying to answer the question: how can environmental insecurity be combated? In 1987, the United Nations published the World Commission on Environment and Development: Our Common Future. This report recognized the increased multilateralism of nations and aimed to find a solution to security issues by combining the environment and development. Expanding on topics expressed in the Stockholm Conference, the report established a new notion known as sustainable development. Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Combining socio-economic issues with that of the environment, sustainable development is a strategy that investigates how different forms of security can be achieved through sustainable means (Hopwood, 2005). Sustainable development is one of the key strategies or 'ideological infrastructures' that seeks to uphold the securitization of environmental insecurity within the current capitalistic global system.

Since the report was published, the concept of sustainable development has cultivated amenable definitions and interpretations; however, Our Common Futures interpretation has stayed the standard within contemporary international politics (Dalby, 2022). It can be seen how key themes of sustainability that stemmed from the original 1987 report influenced environmental governance just five years later at the 1992 Rio de Janeiro United Nations Conference on Environment and Development (UNCED, 1992). The 1992 Rio Conference constituted an acknowledgement by the international community that anthropogenic practices were a severe threat. It became clear that the increase in supply and demand of natural resources triggered 'a vicious cycle of human and resource impoverishment' (Mathews, 1989). Patterns of consumerism that were largely prompted by the global north amplified the mass agriculture

and industrial practices needed to obtain those natural resources. The repercussions of such economic patterns were, in turn, destroying the entire planet, especially the global south. During the conference, leaders of the global south expressed their concerns as to whose future was being considered. The discussions that came out of the conference led to a report outlining intentions to focus on individual, community, and ecological security. The meeting led to the creation of two critical conventions: the first was the United Nations Framework Convention on Climate Change (UNFCCC), and the second was the Convention on Biological Diversity (CBD). Today, both conventions have become well-established institutions that facilitate environmental governance. While the intentions of the actors involved in the conference were positive, the world was still under a neoliberalist understanding of security, and the intentions set by the UN were not effectively combating environmental degradation (Floyd and Matthew, 2013).

Following the Rio Conference came the Kyoto Protocol, which was signed in 1997 and became effective in 2005. The protocol implemented the objectives set out by the UNFCCC, emphasizing the need for the reduction of carbon emissions and providing a legally binding obligation to ensure nation-state participation (UNFCCC, 1992). Again, it was expressed how the actions and economic patterns of the global north were the main instigators of rising GHG emissions and the destruction of the natural system (Floyd and Matthew, 2013). The coming years would show a similar push for sustainability as multiple international treaties, protocols, and policies were established to counter environmental insecurity. Another significant issuance was the UN's Millennium Declaration in 2000 which set forth sustainable commitments that later led to the establishment of the Millennium Development Goals (MDGs). The idea was that the eight MDGs would be achieved by 2015. Despite the initiative that was shown, critics believed that the issuance showed little analysis and justification for the eight specific objectives, lack of measurement, and too short a timeframe to achieve the goals (Fehling, Nelson, and Venkatapuram, 2013).

Although there was an increase in summits and conferences that were focused more on the interwoven global threats created by environmental degradation, little action was being taken to support the resolutions agreed upon (Floyd and Matthew, 2013). It was not until 2015 that the world would see a turning point in sustainable affairs with the establishment of the Sustainable Development Goals (SDGs) in the 2030 Agenda and the 2015 Paris Agreement.

Unlike other international attempts to mitigate against an extensive list of environmental security threats, the Paris Agreement and SDGs were the first initiatives that aimed to implement practical actions against climate challenges. The Paris Agreement was a global promise to try and reduce GHG emissions, with the ultimate intention of reaching net zero carbon emissions by 2050 (UNFCCC, 2016). As the world was entering a new era of climate change, there was a broader focus on providing financial assistance to countries most affected by the climate crisis. The countries that agreed to spread sustainable development worldwide came together for these new agreements and reviewed how effective global implementation of sustainable practices actually was. The Paris Agreement then took these reviews and amplified its target standards by creating a binding agreement. The countries that chose to adopt the binding agreement would now need to adhere to mandatory measures in their attempt to lower their nation's carbon emissions (Adnan, 2022).

Building on the MDGs, the 2030 Agenda is a strategy framework that seeks to mobilize joint-stakeholder collaboration in order to achieve sustainable development. The 2030 Agenda determined a new universal plan to integrate the core components of sustainable development (economic, social, and environmental dimensions) to attack insecurity across five target areas: people, planet, prosperity, peace, and partnership (UN DESA, 2015). Reaffirming the principles laid out by other major UN conferences and summits that came before it, the new Agenda built a new foundation for sustainable development. The Agenda states, "The challenges and commitments contained in these major conferences and summits are interrelated and call for integrated solutions. To address them effectively, a new approach is needed (UN DESA, 2015)." Signed by 193 nations, the treaty addressed the desire to resolve people-centric security issues, protect the planet and its natural resources, and create a more inclusive, sustainable economy. The 2030 Agenda sets out 17 Sustainable Development Goals (SDGs) and targets seen in Table 1.

Table 1: 2030 Agenda Sustainable Development Goals

Sustainable Development Goals			
Goal 1	End poverty in all its forms everywhere	**Goal 10**	Reduce inequality within and among countries

Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	**Goal 11**	Make cities and human settlements inclusive, safe, resilient, and sustainable
Goal 3	Ensure healthy lives and promote well-being for all at all ages	**Goal 12**	Ensure sustainable consumption and production patterns
Goal 4	Ensure inclusive and equitable quality of education and promote lifelong learning opportunities	**Goal 13**	Take urgent action to combat climate change and its impacts
Goal 5	Achieve gender equality and empower all women and girls	**Goal 14**	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
Goal 6	Ensure availability and sustainable management of water and sanitation for all	**Goal 15**	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 7	Ensure access to affordable, reliable, sustainable, and modern energy for all	**Goal 16**	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels
Goal 8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all	**Goal 17**	Strengthen the means of implementation and revitalize the global partnership for sustainable development
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation		

Source: United Nations Department of Economic and Social Affairs (2015) 'Transforming our World: The 2030 Agenda for Sustainable Development'

The SDGs are a set of goals that were decided upon as the essential needs and rights for humanity to uphold. They are a blueprint for new standards meant to guide stakeholders in a transition to a more sustainable world. Similar to the ambiguous, interconnected nature of the threats that SDGs are trying to solve, Sustainable Development Goals are all inextricably linked. For example, consider Sustainable Development Goal Nine (fostering of new industry, innovation, and infrastructure). The development and implementation of favourable technology can also help achieve other goals, such as SDG Eight (decent work and economic growth), by creating opportunities for higher export performances, more efficient industry operations, and

employability. This, in turn, could help fix or mitigate other goals, such as SDG One, which aims at ending poverty due to higher income levels and more profitable labour markets.

Across sectors, these goals have become the standard for human and environmental security. In 2021, the 26th annual UN Climate Change Conference (COP26) was held in Glasgow, United Kingdom. At COP26, the performance of countries that legally pledged themselves to the Paris Agreement and the 2030 Agenda were once again reviewed. Despite the nations' commitment to meeting the 2030 goals, most governments scored drastically below emission targets (Adnan, 2022). Today, a confluence of crises, including but not limited to COVID-19 and the war on Ukraine, have also further pushed back target numbers set out by the Paris Agreement (UN DESA, 2022). Many of the countries are in grave danger of not accomplishing the SDGs and lowering their carbon emissions. While governments are off the designated timeline for sustainability, the urgent global climate crisis has created a push for environmental security: a push that is shaping the future of innovation and strategy to combat the interrelated list of threats affecting our planet.

3.2 Innovation as a Tool of Sustainable Development

Innovation can be defined as "the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality" (Taylor, 2017). By this definition, innovation is a tool implemented into society with the aim to produce an outcome that adds both practicality and value; as such, innovation is intrinsically linked with human and economic development. Since the Industrial Revolution, the world has gravitated towards a capitalistic paradigm controlled by trade and industry. Due to this, nations wanting to gain a competitive edge strive for economic and market dominance. The current international system that society presides in is predominantly ruled under realist approaches. Under realist logic, nations seeking safety consider security value in economic growth and the profitability it brings, thus making economic growth a means to power and control (Asaro, 2019). Due to this systematic dynamic, governance and investments are driven by trade, expansion of infrastructure, and the promotion of innovation (Tomaselli et al., 2019). To gain a competitive advantage, nations focus on increasing their per capita and maintaining a dominant position in global trade. As a tool for economic growth, technological advancements have an immense impact on a nation's safety.

Today, there is a push for a new global paradigm, one that seeks a greener future. When the changing climate is considered a security threat, environmental security can allow for the transition away from standards set out by capitalism and push towards new standards that prioritize the safety of the planet. Making economic and human development more sustainable also requires a shift in the roles and values set out for innovation (Tomaselli et al., 2019). In the SDG goals, the United Nations created a specific target to achieve sustainability through industry, innovation, and infrastructure. SDG Nine states a broad target for the need to 'foster innovation.' Cross-collaborative initiatives are being set up to create resilient and inclusive infrastructure, promote industrialization, increase financial services and markets, enhance research, support domestic developmental projects of technology in the Global South, advance communications technology, and increase access to information technology (Schwind, 2019). Technology, which is used across every sector, is now being reoriented towards humanitarian societal needs and the reduction of inequality.

3.3 Deforestation and the Amazon Rainforest

The spreading impacts of environmental problems have led to an array of interrelated challenges. The current global economy relies heavily on carbon across all sectors. A continuously rising number, roughly 50 billion tons of greenhouse gases are emitted annually (Richie and Roser, 2020). Of that 50 billion, about one-quarter of the emission comes from agriculture, forestry, and land use; data suggests that it emits 18.4% of CO2, the second highest sector after energy (Richie and Roser, 2020). While CO2 emissions across sectors are interwoven, it is essential to understand the nuances of the individual contribution of subcategories within each industry. Under the land use, forestry, and agriculture sector, subsectors include deforestation, agriculture soil, livestock and manure, and crop burning. Today, agriculture has become the world's largest industry, with pastures and croplands making up approximately 50% of Earth's habitual land (World Wildlife Fund, 2022). It is an industry that has fueled increased production at the cost of the environment. Furthermore, much of the energy is used to power the extensive agricultural practices (Richie and Roser, 2020). The world has fallen into a capitalistic paradigm in which consumerism prompts mass anthropogenic practices.

In 2022, the annual Sustainable Development Goal update reported that agricultural expansion is the cause of almost 90% of global deforestation, or the intentional clearing of

forests (UN DESA, 2022). Deforestation takes many forms, including logging for timber, agriculture clearcutting, wildfires, slash-and-burn, and livestock ranching. These anthropogenic practices not only affect the physical world but also increase global carbon emissions. Mass deforestation is seen worldwide, and its effects are considered a chief contributor to climate change (Sutter, 2019). The impacts of deforestation, whether direct or indirect, leave a trail of trouble. In addition to the implications, it has on global warming, deforestation causes the loss of biodiversity and destruction of habitats. Tropical rainforests alone hold roughly 50% of the species on Earth. Clearing of forest land destroys the habitats and leads to the decrease, destruction, or extinction of plants and animals (NASA, n.d.).

Other critical issues that come from deforestation are floods and droughts. Regarding floods, when trees are no longer there, rainwater moves faster and picks up sediment along the way, which then fills the rivers and streams (Bjornlund, 2010). When streams no longer have the capacity to hold water, the water spills over, causing flooding. Trees help mitigate droughts because their roots form a barrier that funnels water into underground aquifers, storing it for later when there is a need for it. When deforestation occurs, there are no longer trees to keep the water, increasing droughts. Droughts are a common occurrence in many West African countries and have been a key instigator of widespread hunger and famine (Bjornlund, 2010). Deforestation also causes increased soil erosion and landslides. When trees are removed, essential nutrients from the soil are washed away by rainwater. This, in turn, reduces the fertility of the soil and can ruin agriculture and productive farming. Moreover, unethical agriculture practices increase the extraction and depletion of natural resources. Deforestation can also have negative economic impacts as unsustainable forest management can leave forest-based populations more vulnerable. Land grants and logging or mining companies have forced the displacement of indigenous groups, and, in many cases, led to violent confrontations (Bjornlund, 2010). Illegal logging is how most of the deforestation in the Amazon happens. The Brazilian government has had trouble over the years with stopping the illicit practices due to the size of the rainforest in Brazil's territory (Silva, Castro-Gamboa, and Bolzani, 2010). In addition, the current administration has prioritised economic benefits by logging in the Amazon over stopping the damaging practices.

Deforestation is especially dangerous for biospheres deemed global commons or a domain considered a shared pool of resources for everyone (UNEP, 2011). One such domain is the

Amazon Rainforest. As it is the largest tropical rainforest, the Amazon Rainforest is one of the richest biomes on the planet. Since the 1960s, the size of the Amazon has drastically shrunk as a result of the clearance of the forestland. The high levels of crop-burning and cattle production have left the tropical rainforest in a state of no return. Current reports show that this year, the Amazon has hit its highest annual level of deforestation in a decade (Milhorance, 2021). For a short period, the Amazon was showing signs of improvement in deforestation practices when policies were implemented that intended to punish anyone logging or farming in restricted forest areas. However, with soy and cattle production bringing in increased revenue, the enforcement of these laws went down while deforestation went up again (Burrow, 2019).

3.4 Sources of Innovation and the Amazon

Sources of innovation can bring both benefits and disadvantages, depending on the referent object. Over the years there have been multiple sources of innovation that have been implemented into the Amazon Rainforest. Some of these innovations have prioritized economic outputs, while others sought to combat deforestation. Two of the most impactful over the past few decades have been roads and satellites, each innovation fostered for different priorities. Looking at the Amazon Rainforest, infrastructural developments such as roads can be considered advantageous when considering economic benefits. With more roads there was easier access for logging and agriculture. Due to this, there was an increase in mass resource extraction which in turn led to higher economic growth in Brazil due to increased exports bringing in more capital (Tomaselli et al., 2019). Similarly, global consumers in the West benefit from road development in the Amazon as they have more access to raw materials that are needed for the materialistic items those consumers' desire. However, on a local level, road construction hinders smaller and medium forest-related enterprises through factors such as competitive pricing against larger businesses and timely delivery of products (Macqueen, 2008). Furthermore, while roads lead to increased access to valuable timber, they also risk future unsustainable deforestation practices as a symptom Brazilian weak governance (Tomaselli et al., 2019). Roads have led to increased agriculture, making it one of the leading drivers of deforestation. In 2014, approximately 95% of deforestation in the Amazon was within a 1 km to 5.5 km radius from transportation networks. Looking at the impact of roads on forest-based biospheres, there is a direct relation between roads and deforestation (Barber et al., 2014).

One of the more important technologies contributing to slowing down deforestation has been space-based forest monitoring systems. The ability of satellites to quickly survey huge areas that are difficult to assess and even access from the ground is unmatched by other technologies. The Brazilian government first put this technology to use in 1988 with the establishment of the PRODES data-collection system. Later, in 2004, a second system called DETER was developed and would instead make use of daily observations of fires, deforestation, and vegetation health. Deforestation alerts were sent to rangers and enforcement officers in under two weeks when the system was first established, but by 2011 these updates took place in under a day. This meant that enforcement officers could, armed with satellite images, proactively search areas with recent deforestation activity and confiscate equipment and issue fines. This technology made those responsible for deforestation more cautious as "the existence of DETER meant that environmental authorities would likely notice if large tracts of land were cleared, and fines and agents would follow soon enough" (Voiland, 2019). Later, the technology advanced and Synthetic Aperture Radar (SAR) satellite were created, which could see vegetation through clouds, working day and night (Rahman and Sumantyo, 2010).

Although this technology has been available for use since at least the 1980's its application to the issue of deforestation monitoring in the Amazon remains 'comparatively unexplored' (Ortega et al, 2021). Part of the reason SAR technology has been underexploited is political. The DETER rapid alert program was considered a 'cornerstone of the Brazilian government's strategy to reduce deforestation' when it launched in 2004 (Sales et al., 2022). However, it was known by the developers and the wider scientific community that the system would not be able to overcome the issue of cloud cover blocking the production of useful data. Despite SAR data being made publicly available by various space agencies, such data was not incorporated into the rapid response systems (Sales et al., 2022). Indeed, even the data and systems that do exist have come under intense political scrutiny. President Bolsonaro, whose corporate-friendly approach to forestry management led to a sharp rise in deforestation, sought to discredit the National Institute of Space Research, conspiratorially claiming that its director was beholden to outside agents and that information produced by the agency is 'a lie' (Escobar, 2019).

This literature review, by examining traditional and critical schools of thought, placed the issue of environmental security within the broader theoretical context of security studies. It has taken a closer look at innovation, deforestation, and sustainable development, shining a light

on the interaction that exists between them. More closely, it explains deforestation in the Amazon Rainforest and how two different critical sources of innovation have been implemented into the Amazon. Technology is one of the most powerful components of the world. It is a central part of our identity and permeates into the most significant parts of our lives. Furthermore, with the twenty-first century entering a digital world, emerging technologies are quickly taking the position as the most influential pieces of innovation (Asaro, 2019). With technology playing such a critical role in society, there needs to be more of an understanding of the complex dynamics that are driving the designs, operations, implementation, and measurements of technology. This dissertation seeks to investigate the relationships between digital technology and sustainability, looking further into if sustainable solutions are effectively countering environmental insecurity.

4. Research Question, Methodology and Design

Environmental degradation is a unique and uniquely threatening collection of problems. In response, the international community came together to coordinate and structure a framework on how to deal with these problems. Part of this response took shape with the 2015 SDGs, which have become the standard targets to reach a greener future. Governments, civil society, and the private sector have now begun to implement the goals as measures for sustainability. Governments use these as sustainable standards to shift their regulations, civil society raises awareness and tries to implement them in their daily life, while the private sector aims to transition their business models towards sustainability. The issue is that with so many goals to tackle and so many methods, each sector holds different standards for the term sustainable. That lack of unified understanding, in turn, influences how tools for sustainability are understood and their impacts on the threats being considered. Should significant divergences in understanding continue to occur, progress towards achieving these goals may encounter avoidable and unnecessary obstacles. This dissertation seeks to further investigate the impacts of innovation and how those impacts mean different things to different actors. To do this, the research considers the case of one emerging technology and its impact on deforestation in the Amazon Rainforest. The research will assess the evolution of AI and a specific case in which AI is being implemented into projects helping to mitigate deforestation in the Amazon Rainforest. The research will seek to use a combination of a comparative and exploratory case study to explain how AI is implemented into sustainable solutions against deforestation in the

Amazon. The case seeks to give insight into the evolution of Artificial Intelligence and how that may influence our understanding of the technology. This will then lead to further analysis which seeks to pose insight into AI's implementation impact against a particular insecurity. The findings will then lead to the further discussion surrounding a much larger issue in the inconsistency in metrics of sources of innovation for sustainable development. This part of the dissertation will be sectioned into seven parts: gap within the research; the research question; research methodology; research design; the analysis framework; limitations; and overview.

4.1 Issue and Gap in the Research

Over the past two decades, there has been a global wake-up call against the pressing dangers of environmental insecurity. It is this understanding of the severity of the global crisis that has led to conceptualizing security through the lens of sustainability. Environmental security risks are complex, messy, and intertwined. They hold no disciplinary boundaries, and the same holds true for the methods put in place to securitize those threats. Achieving sustainability requires a trans-disciplinary effort, connecting actors across different sectors. The problem then is that when solutions are implemented, it is difficult to understand whether those solutions are successful in combating environmental security, especially when considered from the perspectives of different stakeholders. The multitudinous expectations and values that come from those various stakeholders then drive the metrics of assessment. Innovation is a tool that is considered by most actors as a critical contributor to mitigating environmental degradation. Over the last decade, new technologies have been created or oriented towards generating both ecological and social movements aimed at achieving environmental security. Innovation bears a similar challenge when it comes to interpretations of effectiveness. The expectations used to evaluate the impact of new technology create the issue of taxonomy. It is this lack of consensus that leads to no uniform metrics for measuring the effectiveness of sustainable innovation. Sustainability is a relatively recent idea to society, and the impacts of sustainable development are still in the process of being understood. Today, sustainable development is pushing to the centre of political conversation, requiring new methods of measurement. A way to critically evaluate social, economic, and ecological factors, the drafters of SDGs intended for sustainable development to be understood as the implementation of strategies that work toward building a greener future (UNDESA, 2015). Emerging technologies are one tool in the solutions being used to achieve a sustainable future. Like sustainable development, emerging technologies are

quickly evolving, and the impact of such technologies is still being considered. There is an ongoing need to evaluate and understand how emerging technologies are being used to achieve sustainable development goals, and, more importantly, whether those impact assessments are aligned amongst stakeholders. This dissertation seeks to analyse the impact of emerging innovation and how that innovation is realistically evaluated.

4.2 Research Question

There is no question of the value that sources of innovation pose in the fight against environmental insecurity. The issue comes, however, from evaluating the effects of that technology.

This poses the following questions:

> *What are the impacts of innovation in terms of sustainability; specifically, how have emerging technologies altered sustainable practices in relation to deforestation in the Amazon rainforest?*

With the multitude of insecurities that sustainable development is trying to combat, the research seeks to narrow the scope down by focusing on relevant emerging technology and its association with a particular environmental threat. The research will seek to answer the first question posed by focusing the data on Artificial Intelligence and its effects on sustainable practices against Amazonian deforestation. The results will then be used to further analyse a more general second question:

> *What is considered 'effectiveness' in sources of innovation in terms of sustainable development practices?*

The second question will be considered in the discussion, focusing on a more theoretical explanation of the critical challenges posed by misaligned ideas of success, especially in regard to the private sector.

4.3 Research Methodology

The research will use a case study as the method of analysis, focused on Artificial Intelligence as the innovation and its alterations on sustainable practices against deforestation in the Amazon Rainforest. The research will be a combination of two types of case studies:

exploratory case study and comparative case study. As an explanatory case study, the research will seek to further investigate the extents to which the particular case bears out a broader class of instances (Kanazawa, 2018). The case used in this dissertation will pose as an example to explain a broader question regarding the impacts that innovation has on sustainable development. As a qualitative comparative case, this research will explore a more general comparison of historical and current understandings of Artificial Intelligence in order to navigate the relationship between humans and a particular source of innovation.

The emerging technology that is going to be considered in this study is Artificial Intelligence. To start the first case will look at a more historical understanding of what purpose Artificial Intelligence was created for and how it has evolved. The next part will show a particular case in which Artificial Intelligence is implemented into development projects associated with mitigating deforestation in the Amazon Rainforest. The case will investigate projects from a research institution known as Imazon that focuses on information-gathering as a method against deforestation. As technology is considered a part of the solution to environmental insecurity, there needs to be a clearer understanding of the relationship that highly evolving technologies have with environmental insecurity. Often research studies look at the relationship between larger systems like satellites and their impact on sustainability. Within those multidimensional digital systems, Artificial Intelligence is a critical supporting application. An ever-expanding tool, its influence has changed the way that digital systems work across all sectors. This research aims to narrow the focus and expand on the case of Artificial Intelligence not only due to its crucial role in modern digital networks, but also because of its secondary nature when considering emerging technology and sustainability. By considering AI as the exploratory case object within this study, the dissertation seeks to narrow the research down to a technology that is less explored through the lens of the environment.

The unit of analysis chosen to analyse the case will be using the Social Construction of Technology method and theoretical framework, which will be further explained in the Framework of Analysis section. Multiple units of analysis seek to examine a more complex picture by giving more perspectives on different understandings of the technology depending on the stakeholder in question (Kanazawa, 2018). Having multiple units of analysis aims to give the reader a more complete picture of the complexity and understanding of how implemented technology is considered a solution to sustainability.

4.4 Research Design

In Salter's 2013 explanation of research designs, he explains four crucial considerations: (1) *object of analysis, (2) research question(s), (3) data that counts as true, (4) and the way the data is interpreted* (Salter, 2013*)*. For this research, the *(1) object of analysis* will be the different implementations of AI, both historically and on projects related to deforestation within the Amazon. The first *(2) research question* looks at the impact of innovation on sustainable development. To start, there will be an analysis of the original purpose that Artificial Intelligence was created for, to get an understanding of why the technology was created. Then, in order to narrow the broader question of innovations' impact on sustainable development, a more focused one will guide the research to investigate how the technologies alter sustainable development practices using a case of AI in combating deforestation in the Brazilian Amazon Rainforest. The information gathered from the cases will then lead to a discussion on the broader question focused on inconsistent metrics of sustainable success. In this research *(3), the data that counts as true* will use a collection of secondary sources, including quantitative measures of deforestation, historical papers, government documents, research from institutions, and information found from additional scholarly research. These sources of data will seek to provide evidence as to the impact that Artificial Intelligence has on sustainable practices across various stakeholders when considering deforestation as a security threat. The final step of the analysis, *(4) the way the data is interpreted,* will use a text-based analysis using SCOT framework to assess the collection of data. An interpretivist research design, this research aims to use the information gathered as a new case to explain the impacts of emerging technologies on sustainability and sustainable practices. The findings from the case will seek to further open discussion on the pressing issue of inconsistent impact assessment; more specifically, in the measure of the effectiveness of innovation with regards to sustainable development.

Once the parameters of the research design are set up, the researcher must make sure that the quality of the work is clear, consistent, and concise. Typically, in research design setups, the research question is made to be clear-cute and has the ability to effectively identify core relations between subjects (Salter, 2013). However, the unambiguousness found in the research question does not necessarily translate to the method aimed at answering the research question. The conceptualization, explanation, and presentation of the research can be incredibly complex. In interpretivist methods, the analysis is the means to make sense of the complexities that arise

from a seemingly clear question. Different from other research, social and political interpretivists believe in two key concepts: one, that agency is everywhere, and two, causality is emergent (Salter, 2013). Thus, it is in the hands of the intellectual to explore how to identify *clarity* from emergent causalities prompted by the research question. Unlike other methods that seek to understand efficient causality, this research will take an interpretivist approach, one in which data collection and retention will not be straightforward. The research will seek to find a "complex web of facilitating conditions, localized spheres of influence, and networks of embodied, feeling actors (Salter, 2013, p. 16)." This research seeks to analyse how AI alters sustainable practices in the context of deforestation in the Amazon Rainforest. The narrower scope provides more insight and clarity to a much larger phenomenon: identifying how innovation impacts sustainable development practices for the purpose of environmental security. Furthermore, the key findings and information found will highlight the problem of metrics of success in environmental security solutions. When considering the *fit* of a research design, it must be understood that there are different methods that can be used to understand the same complex topic of study (Salter, 2013). Methods are the tool for breaking down the topic and its complexity into a narrative that is understandable. As explained earlier, this research will use a case of Artificial Intelligence implemented in development projects as a way to try and identify a correlation between emerging sources of innovation *(Artificial Intelligence)* and their impacts on securitizing a specific environmental threat (*sustainable practices used to combat deforestation in the Brazilian Amazon Rainforest*). A comparative, exploratory case was chosen as the fit method for this dissertation for two reasons. One, it is a way to narrow the focus of a much larger phenomenon down to a particular circumstance. Two, it allows for a more general understanding of what Artificial Intelligence was originally created for and highlights Artificial Intelligence as a supporting tool for systems that facilitate sustainable practices.

Reflexivity explains how the position of the researcher is crucial in research design. The researchers' personal standpoints on the world will influence unquestioned assumptions and the way that the research will be presented. Personal opinions on dimensions including politics, philosophy, economics, culture, and security will intrinsically influence the analysis of the research and the data collected. "There is a necessary translation required between the language and the genre of academic and policy worlds, and social, cultural, and symbolic capital changes

value in the translation" (Salter, 2013, p. 22). When translating the data acquired into a clear, fitted research design, it will need to be understood that the conclusions are subjective to interpretations made by the author. The researchers bias as well as understanding of norms and rules will likely transcend into the outcomes concluded. In this research study, the author considers the information under an environmental security perspective, one in which the referent object is dependent on whose security is being considered.

4.5 Framework of Analysis

The research will be using the Social Construction of Technology theory framework using a text-based analysis. Coming from the field of science and technology studies (STS), SCOT is a theory that seeks to understand the dynamic between technology, sociology, and politics. The constructionist theory looks at the co-production between society and technology; it believes that technology is shaped by a variety of societal forces and factors rather than the other way around (Bijker, 2015). Using a heterogenous sociotechnical assemble, SCOT framework analyses technology by considering five major components: *relevant social groups, interpretive flexibility, technological frame, and closure/ stabilization, wider social context* (Bijker, 2012). The theory tries to look at how different social groups and norms affect the use of technology. Using a socio-technical analytical lens, the framework starts off by identifying *relevant social groups*, or the producers and users of the technology. The relevant social group can range from any institution or individual, both organized and unorganized, that shares a set meaning about an artefact. Labelled 'artefact', the technology in question has different meanings, problem-solving focuses, and solution-based designs based on the perceptions of the different relevant social groups. Once social groups are chosen, the different groups are further described in detail to better explain what function the technology plays with respect to each social group as well as the power or economic strengths of these groups (Bijker, 2012). Next is i*nterpretive flexibility.* Interpretive flexibility explains the various understandings that are assigned to a certain artefact by different social groups. In SCOT theory, interpretive flexibility demonstrates that technology is a social construct and moves the conversation of scientific findings away from the natural world and more towards the social world. The understanding of the object goes beyond what different social groups think of an object, but also influences how the object is designed.

With so many different opinions shaping the way that technology works, social groups use a *technological frame* to arrive at a shared meaning of the artefact (Bijker, 2001). The technological frame takes into consideration the various interactions that occur between actors. It allows for an understanding of the artefact that recognizes that there are different inclusion levels between actors and their involvement in, production of, and use of the artefact. As Bijker suggests, there is an element of problem-solving strategies within technological frames that considers and deals with the interactions between different relevant groups. In the process of development of a certain innovation, the technology is continuously constructed and deconstructed through social interactions and factors. Early SCOT theories believe that once the design has been widely accepted by most social groups, it is considered to *stabilize* or find *closure*. Stabilization is not an isolated event, but rather an ongoing process that continues to occur throughout technological development. With different groups having different interpretations of an object, the degree of stability then coincides with a particular group's interests and abilities; abilities including management of resources and legal restrictions. The different interpretations of stabilization then lead to arguments and controversy between the different relevant groups. Closure thus seeks to find consensus between the different social groups. Stabilization and closure do not necessarily mean that an artefact has allowed for a certain problem to 'disappear', but rather that enough people agree on the degree of stability to find closure. This leads to the final concept of *wider social context*, or the connection between closure mechanisms and society. It is important to recognize that relevant actors involved (i.e., consumers, producers, nations, and local communities) will all have a wide range of structural characteristics that dictate the development of an artefact.

By using a SCOT framework analysis, the objective of the research is to explore the web of interconnected actors and priorities that are at play when implementing technology for sustainable practices. A major aspect of SCOT framework considers the prioritization of social needs (Norcliffe, 2020). In the twenty-first century, with the rising levels of GHG emissions and degradation of nature, there is a social need for environmental security. Deforestation is considered the number one security threat in the Brazilian Amazon (Imazon, 2022). Due to this, the analysis looks at deforestation as the environmental insecurity that the artefact, or in this case Artificial Intelligence, has been geared towards resolving. Specifically, the research will focus on a project geared towards mitigating deforestation in the Brazilian Amazon Rainforest.

The second aspect of SCOT is the adaption from the technology's original design to a new one that was not anticipated in that original blueprint (Norcliffe, 2020). Artificial Intelligence has evolved greatly from its original design, adapting to different societal contexts. The first part of the research will focus on the origination of Artificial Intelligence. By understanding what Artificial Intelligence was initially created for, this research aims to see how this technology has been altered and reinterpreted from an environmental perspective. From there, using a case in which AI has been implemented into a deforestation-related project, the analysis will look at what the project is, and the different relevant actors involved. Using a socio-technological lens that prioritizes social phenomena in technological assessment, the analysis seeks to identify the complexity of implementing technology into sustainable development.

Expanding on the idea that different social groups and norms change the intentions of the technology, following the analysis, there will be a discussion that explores the difficulties of assessing the impact of innovation. Using the theory of framing, the discussion will try and consider a more general overview of the misaligned target effects between different stakeholders. Being a political communication theory, framing analysis considers the way an idea or information are presented and believes that it has an immense impact on the understanding and outcome of that information (Carnahan, Hao, and Yan, 2019). Goffman's (1974) concept of framing seeks to understand how a certain idea or information is presented. Understanding the effects of innovation can alter depending on the referent point. While stakeholders may hold some of the same measurements for successful sustainable development, there are still vast differences in priorities between the actors. With different priorities come different ambitions for a solution, thus a different framework for the solution. The same holds true for measuring the implementation of technology used for sustainable purposes.

4.6 Limitations

There are a few limitations in the study that must be addressed. The first limitation that may affect the research is dislocation. While dislocation may have its benefits, it also brings limitations through a lack of contextual understanding of socio-economic and localized agencies at play. Moreover, there may be issues of bias and narrative from the other sources that will be analysed. The next limitation will be that the case analysis will only look at a few of the key critical social groups involved. With so many actors directly or indirectly involved

with both the creation of AI and Imazon projects using AI, it is not feasible to explain every single one in full detail within this dissertation. Another limitation that must be acknowledged in the study is the language barrier. As the location that the dissertation focuses on is the Brazilian Amazon Rainforest, many of the documents are in Portuguese. While many of the Imazon reports were translated into English, the latest Imazon Activity Report was not yet translated from Portuguese. Furthermore, there were governmental documents and publications from relevant institutes that had also not been translated into English.

4.7 Overview Summary

To summarize, the research question that this dissertation seeks to answer is 'What are the impacts of innovation in terms of sustainability; specifically, how have emerging technologies altered sustainable practices in relation to deforestation in the Amazon rainforest'? To do this, the analysis will look at a case of a particular emerging technology (artificial intelligence) in an evolutionary context and in its implementation within sustainable development projects aimed at mitigating deforestation in the Brazilian Amazon Rainforest. The first part will look at the historical interpretations of what Artificial Intelligence was used for as a way to explain how that perception has changed to what it is today. Then, there will be an analysis of Imazon and the organisations AI-related projects using a socio-technical perspective. The information and findings will then lead to a further discussion that considers a much more pressing issue regarding measures of success. The discussion will aim to explore the second question, 'What is considered 'effectiveness' in sources of innovation in terms of sustainable development practices?'

5. Analysis

When society thinks of Artificial Intelligence, often there is a façade of this dystopian future that can come to mind. Movie perceptions of flying cars and cyber-cops paint an idea in which robotic machines will take over the world. This glamorously Hollywoodized idea of 'super intelligence' does not exactly match the current truth of what Artificial Intelligence and other digital technologies are capable of. While the 'grand dream' of AI depicts it as a long-term plan of building intelligent machines with a full range of capabilities similar to that of humans, the reality is that humans do not fully understand the technology that we have created. Modern AI is "focused around getting machines to do specific tasks that currently require

human brains… and for which conventional computing techniques provide no solution (Woolridge, 2021, p. 9).” The constantly transitioning understanding of AI brings contentiousness that makes it difficult to really attach meaning to the technology. This research seeks to analyse how Artificial Intelligence has transitioned from the discipline’s early uses and how its ‘purpose’ has changed over the years due to the specific social context. In order to do this, the case will look at the background of the discipline of Artificial Intelligence, what Artificial Intelligence does in today’s society, and how it is being used for sustainability. Then there will be a case of how the technology is being implemented into development projects launched by the institute Imazon in order to combat deforestation in the Amazon Rainforest.

5.1 The Turing Machine and the origin of Artificial Intelligence

The establishment of Artificial Intelligence started shortly after the creation of computers post World War II. The story of AI does not necessarily have a single starting point. Despite the theorizing of machines that embody human life, the story of its initial computation begins in 1935 at King’s College, Cambridge. Alan Turing, a mathematician best known for his code-breaking work to end the World War, is referred to by computer scientists as the inventor of computers, and later the inventor of the field of AI (Woolridge, 2021). What led to the establishment of Turing’s problem-solving machine was a precocious math problem known as the Entscheidungsproblem. In the mathematical world, this problem is known as a decision problem, or one that has a yes or no answer. At the time, mathematical problems were only considered as solvable through recipes and formulas. It is due to this that solving the Entscheidungproblemset set out a further, more fundamental question in mathematics that believed mathematical methods did not require any intelligence in their application (Woolridge, 2021). The Entscheidungsproblem seeks to find out whether all math problems are decidable through a recipe, or if there are some that the answer cannot be found to through a specific list of instructions. Turing was determined to find this out. To prove the Entscheidungsproblem question that all problems could be solved, Turing invented a problem-solving machine known as Turing’s Machines. The machine used a framework that was programmed to solve any associated input that was plugged into it. The Turing Machine thus aimed to prove that any mathematical problem could be solved through a recipe. However, his mathematical idea led to further inquiries in which Turing considered whether a Turing Machine could be used to solve questions about other Turing Machines. A much more albeit decision problem to solve, Turing

realized that trying to solve a Turing Machine's decision problem led to a contradiction because there was no recipe to follow. By creating an undecidable problem, Turing answered the Entscheidungsproblem and established that math problems could not be reduced to merely following a recipe.

Through his machine, Turing discovered that mathematical visions could, in fact, be a practical reality (Woolridge, 2021). Following this discovery came the revelation of computers. Considered electric brains, computers are extremely valuable to humanity and help with problem-solving. Even though the computer could help with extremely difficult challenges, it was not using intelligence (Woolridge, 2021). In the same way that Turing Machine was used to solve mathematical decision problems, the Turing Machine was manifested into a physical computer form that did nothing more than execute automated commands that it was given. Thus, the Turing Machine was just a tool for following instructions. Those instructions given to a Turing Machine in the form of a computer are what we could consider today algorithms and or programs (Woolridge, 2021). Understanding what computers are designed to do and not do is a key concept in the field of Artificial Intelligence. AI allows computers and other smart technologies to reliably follow precise instructions in order to make decisions. If every computer can be simplified to understanding a list of instructions, intelligent computers or technology must also be reduced to that simple list of instructions. In the 1950s Turing proposed the Turing Test as a means to silence those who did not believe that computers could 'think' or have intelligence (Woolridge, 2021). His test became the holy grail in the field of Artificial Intelligence. It gave scientists inspiration for future research and inspired a much bigger picture 'grand dream' in the field. Serving as an important part of the story of AI, a simple machine used to solve a mathematics problem paved the way to the test that changed the entire understanding and design of one of the most critical pieces of technology in human history.

5.2 Turing and the War

Turing had indeed devoted his life to the development of theoretical mathematics. The wider social context in which he lived, however, was also important in how he developed those theoretical mathematics. As a British scholar living during the 1940s, he got involved with the fight against Nazi Germany. Interestingly, in those times, theoretical mathematicians were not considered to produce outputs that were relevant to real-world applications. Hence, when the United Kingdom started recruiting people that could break the German codes produced by the

"Enigma Machine," they initially did not think of mathematicians and primarily recruited linguistic experts (McGrayne, 2011). The operational head of the Government Code and Cypher School (GC&CS), however, disagreed and hired Turing to work on breaking the German codes. He quickly developed the 'bombe,' which was used to test "every possible wheel arrangement in an Enigma" and is considered to be one of the main tools for breaking German codes (McGrayne, 2011, p.65). He furthermore employed Bayes' Theorem, a principle also used in AI nowadays, to crack the machines. Importantly, even though this progress was made during the war and Enigma was eventually cracked, all this information needed to be concealed: the UK government forced everyone involved to secrecy, as they wanted to hide from the Soviet Union how far they were in decryption methods. Hence, Turing's scientific development was spurred largely by military incentives provided by World War Two, but it was not made public because of national security reasons. Despite its secrecy, Enigma found closure to the problem it was created to solve. Nevertheless, closure in the project only led to more questions about the technology itself and pushed Turing to look into certain directions that paved the way for his Turing Test.

5.3 The Later Development of AI

Originating from trying to solve a theoretical math problem, today, AI has become a critical piece of technology in our everyday lives. As Turing laid the groundwork for concepts such as algorithms and computers, various other relevant scientists could build on his theory in later years. In 1955, John McCarthy developed the term AI (Kaplan and Haenlein, 2019). Then, in 1956, research really took off after the milestone Dartmouth Conference, which was organized and proposed by a collaboration of academics and practitioners. When the field of Artificial Intelligence was first created, it was the academics and practitioners who were considered the relevant social groups. The focus was mainly on "how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves" (McCarthy et al., 2016, p.12).

Thus, when AI was being developed, it was restricted to a very narrow and select group of people who were mainly interested in theoretical and mathematical issues or in improving processes within the manufacturing of computers. As such, the relevant social group in spurring the discipline of AI, in this instance through the Dartmouth Summer Conference on AI in 1956 is a collaboration between practitioners and academics: McCarthy and Minsky represent the

academic side, Rochester and Shannon represent private companies and practitioners. All four of them have an academic background, and both McCarthy and Shannon were highly educated on the Turing machines as Shannon worked together with Turing and both of them deployed Bayes' theorem for weapons in the war (McGrayne, 2011, p.76). The involvement of, e.g., Rochester shows the interest of private companies such as the IBM Corporation in using AI for their computer manufacturing processes. This group, through the organization of the Dartmouth Conference, set out the path for AI for the next few decades, and therefore was very influential in deciding how the technology would be used.

5.4 Artificial Intelligence Today and Technicalities of AI

Going from using Artificial Intelligence experiments as proof that intelligent computers are possible, Artificial Intelligence has been incorporated into all aspects of society, thus making all of society relevant in the interpretation of AI. AI is now considered to be a milestone piece of technology for our generation (Asaro, 2019). Within a new wider social context, there are new multifaceted, critical challenges that need to be resolved. The complexities of societal dynamics lead to security threats across sectors, including health, transportation, finance, energy conservation, governments, quality of living, water distribution, and the environment. Due to this, there is a grave need to manage and efficiently set up systems that can simplify operations in and across different sectors. With a new digitalized era, societies have begun to implement emerging technologies that seek to find the most optimal solutions needed to mitigate a certain problem (Mosannezadeh and Vettoriato, 2014). Technologies like Information and Communications Technologies (ICTs) that use a web of digital networks have been altered and interpreted to fit a solution to a particular problem depending on the societal problem. Artificial Intelligence plays a critical role in ICT systems as it is the tool that is used to sort through excessive amounts of data that large multi-dimensional networks create (Al-Garadi et al., 2020). Techniques used by AI models are essential in analysing big data and finding the most optimal and influential pieces of information. It is a supporting tool inputted to make a bigger system run.

With the field of AI growing exponentially, a technical background in AI is useful to understand how it could be deployed in sustainable settings. A distinction should be made between AI and machine learning (ML). AI is broader than ML "since it also covers a system's ability to perceive data" (Kaplan & Haenlein, 2019, p.17). Thus, AI also includes applications

such as natural language processing (NLP). NLP is described as "models that predict the probability distribution of language expressions" and are used to "text classification, information retrieval, and information extraction" (Russel and Norvig, 2010, p.860). Hence, this version of AI is incredibly useful for analysing big data. ML is used for similar purposes. There are three different types of learning processes: supervised, unsupervised, and reinforcement learning (Russell & Norvig, 2010). Unsupervised learning means that the machine "learns patterns in the input even though no explicit feedback is supplied" (Russell & Norvig, 2010, p.694). In contrast, supervised learning first needs "labelled examples" to be able to see "patterns to predict the values of the label on additional unlabelled data" (Nathani & Singh, 2021, p.50). Thirdly, reinforcement learning relies on the machine to learn from rewards or punishments and adjusts its classification algorithm accordingly (Russell & Norvig, 2010, p.695). In addition to those types of learning, it is essential to mention deep learning. Deep learning makes use of layers of Artificial Neural Networks (ANN), which can be described as a "network of algorithms" similar to the human brain (Nathani & Singh, 2021, p.59). Importantly, the features in these networks are learned by the machine using the data given to them "using a general-purpose learning procedure" (LeCun, Bengio & Hinton, 2015, p.436). It is the same idea as Turing's Machine but expanded upon to fit the complexities of today's advanced technologies. From improving the recognition of languages, and translation of texts, to helping navigate us through traffic with foresight, AI technologies have firmly been established in our everyday lives. Due to this, AI is one of the most important technologies of digitalization.

Compared to other emerging technologies, applications of Artificial Intelligence have expanded exponentially due to the cheaper and easier ways of creating the technology (Asaro, 2019). In many cases of technological innovation, it would be government funding research and design, making it only accessible to a limited group of inventors (Asaro, 2019). As the creation of Artificial Intelligence takes a digital form, in the twenty-first century, anyone with a computer can create an AI model that is used to maximize a specific set goal. This means that a broader variety of people can engage with the technology. Because of this, AI models are not necessarily ever stabilized as the different types of AI are continuously growing. Rather, stability and closure of AI can be considered only if a certain task or project in which AI models are implemented into have successfully been completed. This makes it difficult to pose one

technological frame for AI as each model is created to solve a variety of challenges. With a plethora of methods to implement AI and to use it for information-analysing purposes, there are continuous interpretations to be measured. When considering sustainability measures, the way that Artificial Intelligence is implemented will depend on who engages with the technology and with which incentive.

5.5 Artificial Intelligence, Sustainability, and Deforestation

Impacting every sector, Artificial Intelligence has enormous potential to solve the ecological challenges that our world faces today. As described in the Literature Review, the wider social context has transitioned from unilateral to multilateral threats. Such threats include those posed by environmental insecurities. It is this wider social context that has reoriented the purpose of Artificial Intelligence to solve environmental insecurity. To do this, Artificial Intelligence has been implemented in various sustainable development initiatives. Artificial Intelligence models are now being programmed to create smart technologies aimed at anticipating, identifying, and combating environmental problems, including air pollution, water pollution, and land degradation (Taghikhah et al., 2022). Outside of the creation of smart environmental-related technologies, AI is a supporting tool that helps with the implementation of environmental policies through means of improving the systems that collect and analyse data used for decision-making.

However, when looking at the social side, from agriculture to forestry, the continuous changes in land use have largely failed to improve community well-being in the Amazon Rainforest (Francesconi et al., 2015). In addition, unethical and unsustainable practices such as timber extraction and palm oil plantations are creating a divide between humans and nature. The anthropogenic practices that drive deforestation are changing the biophysical environment, impacting not only the forest and those who live in it, but the entire planet. If we want to implement solutions to combat the insecurities caused by deforestation, it is important to monitor the changes occurring because of deforestation in a political, socioeconomic, and environmental context. Technologies like temporal and spatial resolution systems that use AI have helped improve the automation of precision agricultural operations, afforestation actions, and initiatives aimed at mitigating the spread of deforestation (Liu et al., 2021). In an increasingly digital environment, innovations such as satellites are used to obtain information and gain an understanding of a certain landscape from a distance. Mapping, image tracking,

and observing are methods that can be used to analyse forest cover and the impacts that are associated with that captured piece of imagery. Due to this, satellites have had an immense impact on forests and forest-based living. However, satellites cannot solve the problem alone. The information that is captured from satellites must then be gathered and sorted by other machines. Technology such as ICT's and Artificial Intelligence are used to compile the data and find patterns for more efficient means to evaluation. Thus, the technologies are combined to create indicators for environmental statistics (UNSD, 2019). Different users, including world leaders, policymakers, the public (from civil society to media sources), and researchers, then assess these statistics and use it as evidence to justify their decision-making. These new sources of innovation have created more efficient ways to share research and data on the environment, offering an opportunity to develop short- and long-term understandings of environmental degradation, such as deforestation and its effects (UNSD, 2019).

5.6 Case of Artificial Intelligence implemented into Imazon developmental projects

The Amazon Institute of People and the Environment (Imazon) is a non-profit research institute that was founded in 1988 but was launched on 10 July 1990. For over two years, the founders deliberated on the goals, principles, and functions of the future institute. Imazon was established based on the research found from studies by other Brazilian institutions focused on tropical humidity as well as research on a number of relevant intellectuals, social groups, and political leaders in the Amazon Rainforest. Imazon's formulation was inspired by the wider social context in the Amazon in relation to the insecurities caused by deforestation. Due to this, Imazon's mission is to "promote conservation and sustainable development in the Amazon" (Imazon, 2018). The institute uses its resources to detect, measure, monitor, and analyse any information related to deforestation, including forest degradation, logging, unauthorized roads, and illegal activities related to the rainforest. Imazon seeks to address environmental concerns and regional planning by monitoring and merging information from satellite imagery with various digital maps, using geographic information systems (GIS). The institution also develops proposals for public policy, programs for geotechnical education and strategically disseminates its results to minimize deforestation and forest degradation. Imazon has maintained a broad and beneficial collaboration with a wide range of public, corporate, and non-governmental institutions, as well as with national and international donors who also helped in funding various projects. For example, Imazon has worked with Google, using Google Earth Image technology

to help monitor the world's tree cover in the Amazon. Furthermore, the institute has partnered with global organizations, including World Resource Institute (WRI), working on a project to develop the Global Forest Watch, a platform which seeks to monitor real-time forest changes. Imazon also collaborates with local level actors from indigenous communities to governmental entities such as the Ministry of Environment

5.6.1 PrevisIA

Currently, Imazon is collaborating with Fundo Vale, a global mining company, and Microsoft to implement an existing rainforest deforestation AI risk model into Azure, a cloud computing service that has been developed by Microsoft. The project is known as PrevisIA and can identify forest-related factors including the tracking of unofficial roads, which is a key indicator for predicting future locations of deforestation. PrevisIA does this by creating risk maps, probability maps, and dashboards that will allow Imazon not only to forecast future deforestation but also to develop danger warnings and employ AI to cover additional regions on a bigger scale. The AI risk model uses the latest technology, making the product more accurate in its predictions while also collecting more data; this is facilitated by a higher-power AI image processing model. As it integrates AI into a development project focused on deforestation, PrevisIA is intended to assess satellite data at a faster and more accessible scale than previous technologies. PrevisIA then distributes its statistics on a public dashboard (https://previsia.org/) with data visualization elements that allow users across sectors to identify available information. As a result, in addition to providing strategic data for governmental entities tasked with protecting the forest, the application facilitates societal participation in the preservation of the Amazon. An initiative created by cross-collaboration, PrevisIA is a problem-solving technology that can be described as seeing AI as a means to prioritise sustainability. As such, the interpretive flexibility of AI has allowed it, in this instance, to push for sustainable solutions. Actors across sectors aim to use the AI model as a means to monitor deforestation, thus allowing both producers and users of the product to use it in an effort to implement sustainable practices.

Furthermore, tools like PrevisIA can help with stopping forest loss and preventing community displacement. Using PrevisIA, Imazon detected that the Katukina/Kaxinawa reserve found in Acre had around 900 square kilometres of land at high risk of deforestation (Ennes and Chaves, 2021). The AI program discovered that 29 different Indigenous territories

and 20 conservation units were included within the 900 square kilometres in danger. Continuously adapting the AI model, the next phase seeks to engage local authorities within the project (Ennes and Chaves, 2021). Part of starting this phase will require creating a benchmark of action with authorities in specific regions. Once there is a true understanding of the impacts of deforestation, the next step will have to consider the implementation of equipment such as infrastructures needed to combat deforestation. This goes to show that PrevisIA is a work in progress and closure has not yet been reached.

5.6.2 Land Regulations and AI: An example of how AI can help change governmental policies

The data that Imazon collects through applications such as PrevisIA is then gathered, assessed, and used to create publications on key characteristics between economic, societal, and environmental relationships focused on deforestation. Afterwards, these publications are used by relevant social groups as evidence to implement environmental change through actors like government entities who have the means to enforce environmental policies. One of Imazon's missions is to create reports for such change. In their 2018 Activities Report, Imazon stated that their research "on community forest management served as the basis for defining national policy for community and family forest management in the Amazon" (Imazon, 2018, p. 6). One example of an Imazon initiative aimed at inspiring change is a recent publication on land tenure. In the report, Imazon highlights the significant increase in deforestation and its relationship with land tenure regulations. The publication used a comparative analysis of the state laws around land tenure and the unethical practices that are currently going on in the Amazon Rainforest. The results found that due to the lack of control over privatizing public land assets, there is no guarantee that the land subsidized by the Brazilian population will be used sustainably. One of the contributors to the problem that Imazon discovered was low-level adoption of technology to effectively organize single or shared land registries (Brito et al., 2021). An undeveloped system for communicating and managing land designation, in turn, causes an absence of transparency in the privatization of land assets. The report aimed to show a clear and direct relationship between the unorganized Brazilian laws and unsustainable practices. Artificial Intelligence has a direct role in the process that Imazon uses to gather information. The pattern-recognition ability of AI models assessing images from GIS systems extracts data in a more accessible way, which is converted into statistics that Imazon uses as evidence in their reports. The translation from a satellite image to qualitative data is directly

linked to the application of AI. A connecting tool, Artificial Intelligence helps present consequentialist approaches to environmental assessment at the political level. From this, consequences of action can be determined, as well as corresponding limits set in resource use or land distribution.

Following the case of land regulation, in an effort to help overcome the challenge of regularization, Imazon partnered with Iterpa, a land-title information management system. Under the Technical Cooperation Agreement, Imazon agreed to help design a system that would better manage and analyse title regulation. Using an AI model, researchers gathered information which they would use to create a case analysis that would be presented to civil society, public prosecution services, the federal government, and the state government of Para (Imazon, 2018). Slow advancements in technology are a major issue in developing countries. In short, Imazon aims to partner with governmental and nongovernmental agencies as a means to help implement new emerging technologies such as Artificial Intelligence, a tool that helps organize and connect digital systems. This creates a common implementation for Artificial Intelligence for the purpose of supporting the Brazilian population.

5.6.3 Ulterior Motives of Big Companies

The relevant social groups involved in Imazon projects range from the producers, large company sponsors, Amazonian governments, environmentalists, and the public, all the way down to the communities that this technology is trying to help. One of the more relevant social groups in implementing AI into deforestation projects is Microsoft. Microsoft, a multinational technology corporation, is a leader in electronic products. Microsoft's mission is to "help people and businesses throughout the world realize their full potential" (Microsoft, n.d.). With the increasing role that technology has in sustainability, Microsoft has begun to reorient part of their business towards sustainability. The company launched AI for Earth in 2017, a program that seeks to empower and organize projects related to minimizing their impact and "maximizing a positive return for the planet (Microsoft, n.d.)." Fundo Vale, another relevant social group, is a non-profit civil society organization that is controlled by Vale. Fundo Vale, or The Vale Fund in English, promotes a more inclusive economy through social and environmental impact business (Fundo Vale, 2021). The fund supports projects aiming to lower carbon emissions. This organization is sponsored and controlled by Vale, one of the largest private mining companies in the world. "Vale is the world's largest producer of iron ore, pellets,

and nickel" (Fundo Vale, 2021). Outside of mining, the company is involved in logistics (i.e., ports, terminals, infrastructure, railways), energy, and steel production.

Both Microsoft and Vale are two influential corporations in the world. Both companies are in sectors that have extremely negative impacts on the environment. For electronics, the process of drilling, mining, manufacturing, distributing, energy usage, and landfills has detrimental effects for the planet. The European Environment Agency (EEA) reported that Europe alone creates over 10 million tons of e-waste a year (Brown, 2021). From common household goods to powerplants that generate electricity, the energy sector is the largest contributor to carbon emissions (Roser and Ritchie, 2020). Metal ores and steel are essential raw materials used in creating different components of electronics. Vale, a mining company, is one of the main distributors of iron and steel, which is further damaging the planet due to the mass extraction of natural resources. While both these companies have committed to creating more sustainable operations, their main businesses are both revolved around some of the most environmentally damaging operations. It is due to this, that major private sector companies are trying to find a compromise, or a new technological frame through projects that aim to mitigate or compensate for some of the damages that are intrinsically linked in both companies' lines of work.

More dominant actors, such as major corporations and governmental amenities, use the services of institutions like Imazon to connect and raise awareness of the physical effects of deforestation, symptoms of deforestation, and instigators that increase unsustainable practices. While institutions like Imazon show great results using state of the art technology, the implementation of that technology does not stop the big corporations from pursuing economic profits in their main businesses, which spur a plethora of environmental insecurities.

5.6.4 Collaboration with Locals

Imazon's ventures do involve not only large, global actors but also local players like indigenous communities or associations representing indigenous communities. With the world becoming more digitalized, there has been a movement to try and merge technological innovation to work alongside Indigenous communities (Oppenner, 2011). A quote from Sia Shanenawa to Mongabay states, "it is very important to monitor the land because we Indigenous people are safer when we can detect if someone is invading if someone is taking wood from our

land if someone is hunting directly on our land if someone is putting a fire close to our land" (Ennes and Chaves, 2021). Sia Shanenawa, is an agroforest agent trained by the non-profit organization Comissao Pro-Indio (CPI). In a similar initiative, Imazon, has partnered with Ideflor-Bio to create the Community Environmental Agent Program. The program implements volunteer agents to actively work with communities in regard to environmental management within their territory. Since 2018, the Program has certified over 60 community environmental agents across four territories (Imazon, 2018). More and more indigenous groups have begun to show interest in welcoming technological innovation that aims to prevent deforestation.

While all the actors and their backgrounds have not been assessed, there are a range of local to global actors involved in the implementation of Imazon projects. Imazon is an institute that has been established specifically to provide information for the safety of the forest. The core value that is displayed among all Imazon projects is sustainability. As the institution is built around the focus of sustainability, all relevant actors working on projects like PrevisIA keep the same technological frame that takes the lens of environmental security. Thus, even though AI is flexible in its interpretation, in this regard the interpretive flexibility driving the design of projects like PrevisIA has an intrinsic focus on sustainability. While AI models are developed using the same list of instructions, the orientation of the projects is framed for a different purpose. Because the research institute's core value is sustainability, the actors' understanding of the projects also must be sustainably oriented. Trying to lower the impact of deforestation is at the core of the institution's mission. However, this does not necessarily show the ulterior motives behind each of the separate actor's participation. This can be seen through Microsoft and Vale, who, despite their sustainable front, are still driven by other motives. In short, Imazon and their projects related to AI can be considered excellent examples of how different levels of stakeholders work together under one goal. However, despite the collaboration and efficient implementation of AI in sustainable projects, deforestation in the Amazon is at its worst. Imazon's latest research reports that Brazilian deforestation is heading towards a new record in 2022, growing almost 70% over the last 15 years. The ripple effects of insecurities caused by deforestation are only getting worse and GHG carbon emissions are on the rise. The implementation of Artificial Intelligence, from its original intentions to now, has only grown more efficient as a tool as can be seen in Imazon's application of AI in

developmental projects; however, the rising numbers of deforestation go to show that the sustainable practices that are being operationalized are not enough.

6. Discussion

From a machine aimed at solving a mathematics problem to a risk model that tracks deforestation patterns, the understanding and implementation of Artificial Intelligence has vastly changed from its first development. The inspiration for the Turing Test, considered the holy grail of the modern field of AI was largely spurred from a tool developed for war. AI's first implementation into the natural world was through Enigma as a means to stop the Second World War. At the time a secret, the creation of Enigma was due to the wider social context being the war and the relevant social groups needing a machine that could crack codes. In the state the world was in during the war, environmental security was not considered a legitimate security threat. Due to this, there was no consideration of the environment and sustainability in the original blueprints of AI. This transition to focus on the environment did not happen until years later. With the increased digitalisation of the world, the field of AI grew exponentially across all sectors, including the environmental sector.

The rising awareness of the global threats posed by environmental degradation led to technology being implemented as a tool for mitigation. Today, environmental security is considered the number one threat our planet faces. Again, the wider social context has reoriented the priorities of society, thus altering the understanding and implementation of knowledge of Artificial Intelligence. This case posed to show how AI models have altered the implementation of sustainable development projects against environmental insecurity. Deforestation, or the mass clearing of the forest, has left a trail of environmental, economic, and social threats to the Brazilian Amazon Rainforest. In an effort to combat deforestation, multi-level stakeholders came together and created initiatives that were specifically created to gather data about deforestation. Imazon, a research institute, has launched projects like PrevisIA that reoriented the technological purpose of Artificial Intelligence towards sustainability. PrevisIA, using the latest deforestation AI risk model, allowed Imazon to create and gather data that monitors the rainforest. Imazon has used Artificial Intelligence as a tool to help the rainforest by creating data that detects illegal logging patterns, forecasts preventive scenarios, tracks biodiversity, produces easier communication networks, advances operations

management, and allows for more efficient means of financial flow. These projects show how AI has been able to alter sustainable projects by establishing environmental statistics through more efficient methods of data collection, sharing, and organisation. Furthermore, AI has also helped advance the operations and logistical side of environmental management-systems. This can be seen in the partnership between Imazon and Iterpa around land tenure title designation. Using Artificial Intelligence, Imazon agreed to help design a system that would better manage and analyse title regulation for the Brazilian government. Showing the ripple effect of what efficient environmental data can do, the case aims to show how environmental data gives critical actors access to information that shows evidence as to the relationships between anthropogenic practices and insecurity. With easier and more efficient collaboration and communication between stakeholders, there are higher chances that sustainable development can be implemented and that environmental policies are approved. The projects launched by Imazon show how a variety of actors can work together to implement innovation in a positive way for the environment.

While development projects like PrevisIA are a step in the right direction, the problem of deforestation has not been solved. Sustainable projects and the AI models they use are continuously changing, thus projects like PrevisIA are a work in progress and using SCOT terms, the project has not found stability or closure. One of the core challenges is that relevant social groups have different understandings of the progress that is being made. This can be seen in the relevant social group of actors working on PrevisIA. The Vale Fund, while sustainably oriented, is controlled by Vale, one of the largest private mining companies. Microsoft, the other main sponsor on the project, is one of the biggest tech companies in the world. Private sector firms that are within some of the most unsustainable industries are the ones controlling or financially sponsoring sustainable development projects. While within the project, Microsoft and Vale are sustainably oriented, the firms' main practices are some of the culprits causing the highest amounts of environmental degradation. Therefore, despite Imazon's core value being sustainability, the companies sponsoring their projects still do not prioritize sustainability over their own business. Thus, with each stakeholder having different incentives for the creation and implementation of innovation, there becomes controversy as to the effects of the product. This issue is exasperated when considering that stakeholders hold different degrees of power and say in product design and meaning. A limitation of Bijkers SCOT theory is the lack of evidence to

show those power dynamics between different social groups involved. Actors in a higher position of power will have more say in the design and implementation of a certain technology. This is something that scholars like Klein and Kleinman have further analysed, explaining that the capacity a group has to develop technology is dependent on that groups position within a particulate structural matrix (Klein and Kleinman, 2002). Within the analysis, there was a lack of consideration of how the private sector (producers) and groups in positions of power (governments) have more say over that of the individuals living on the ground (indigenous groups and local communities).

While not discussed extensively in the case, weak governance can contribute to further challenges. Countries such as Brazil, whose weak governance has direct impacts on Amazonian decisions, can lead to corrupt power dynamics. Those dynamics lead to practices that do not equally benefit all parties involved, especially causing disturbances to locals whose lands are being governed. With weak law enforcement there is a higher likelihood of illegal activities such as unsustainable exploitation of the Amazonian forest's resources. It is why governance plays an integral role in the correct implementation of innovation. Since President Jair Bolsonaro has taken position in office in 2019, there has been a surge in the destruction of the Amazonian Rainforest (Aljazeera, 2022). Under his administration, environmental laws were weakened as they were considered a hinderance to economic development which Bolsonaro's administration believes is the solution to reducing Brazilian poverty. This poses to show how there is a hierarchal prioritization in decision making. The implementation of new infrastructure and technology can offer positive benefits to the Amazon region including economic benefits, job opportunities, and increased quality of life… but at what cost.

6.1 Intrinsic Problem with Artificial Intelligence Research and Design

Despite AI having a positive impact in making sustainable practices more efficient and allowing easier access to environmental statistics, Artificial Intelligence is not a tool merely used for the environment and the systems AI is a part of are not always built for positive humanitarian use. Furthermore, due to AI's integral role in all sectors of society, there are great economic costs that come with creating Artificial Intelligence. Outside of the environmental sector, artificial intelligence has become one of the most influential pieces of technology in this century, holding a high economic value. It is estimated that spending on AI systems will reach $58 billion over the next few years (WebFX, 2021). As a result, both the public and private

sector are investing their capital into Artificial Intelligence research and development. When considering AI in the greater context of society, the producers primary concern is the economic benefit that comes from the product. Their interpretive flexibility is assigned by consumeristic practices and increasing the efficiency in their product for the purpose of the users. Investors are seeking to obtain improvements in accuracy of AI models; AI research revolved around accuracy is known as Red AI (Schwartz et al., 2020). The issue with Red AI is that when accuracy is prioritized the research then is driven by results and disregards the significant financial, social, and environmental costs of gaining those results. AI experiments use an exceptional amount of computational resources and energy consumption to gain those results, not to mention the cost of training and developing of AI models. Studies show that the computational costs of Red AI experiments, one example being Natural Language Processing (NLP) models, have significantly high numbers of carbon emissions (Strubell, Ganesh, and McCallum, 2019). NLP models can emit approximately 1,400 pounds of CO2 and cost somewhere between $4,000 to $12,000 to train in the cloud (Eriksson, 2022). The IDC reported that the cost of both AI software and hardware "is increasing at a CAGR of 24% (Gow, 2020)." With the AI industry on the rise, there is a dire need for a more sustainable strategy in regard to deep learning research and development.

The AI community has recently begun advocating for alternative research activity; activity that is focused on efficiency rather than accuracy. This alternative phenomenon, initiated by Schwartz et al. 2019, is known as Green AI and seeks to veer away from the "state-of the-art" research driven by results, and instead works towards creating a long-term, environmentally friendly research strategy. A more cost-effective method, Green AI encourages AI practitioners to reduce the number of resources that are used in the research and development process. The goal is to find a process that allows for the improvement of performance, or minimal reduction of performance, on a given budget. AI research needs to have a more concrete method of measurement for cost-effectiveness. One suggestion is to use floating-point operations (FPO) as a means to measure running time of a model, energy consumption, and facility comparison with different models (Schwartz et al., 2020). Using FPO estimates would allow project managers a more concrete measurement to analyse, evaluate, and implement strategies that reduce some of the environmental and financial costs. Green AI and the processes that are coming out of it are one example of how technology is being shaped by the wider social context.

Producers are thus trying to solve the problem of unsustainable operations within AI development as a means try and reach a consensus between other relevant social groups.

The exponential evolvement of emerging technologies, like Artificial Intelligence, and increased interconnectivity between digital networks is likely only going to increase moving forward. Despite the benefits that Artificial Intelligence models have brought to sustainable development, the unforeseen environmental cost of the research and application is becoming an emerging issue. With industries investing immense amount of capital into the Artificial Intelligence sector, it is essential that the research and development surrounding AI models and systems shift their focus to a more sustainable method of experimentation. While projects like PrevisIA show how Artificial Intelligence is effectively used in sustainable development projects, that effectiveness comes at a computational cost and furthermore does not show effective results in combating deforestation.

6.2 Framing for Impact Assessment

The continuous pattern of prioritization that is seen not only in the research, development, and implementation process of Artificial Intelligence, but also in the overall impact assessment and measures of effectiveness. Despite the positive numbers that are shown through environmental data, deforestation is still on the rise. In just the first three months of 2022, Brazil has hit record numbers in deforestation, rising 64% from last year (Aljazeera, 2022). The impacts of anthropogenic practices are increasing at an exponential pace. Deforestation is just one of the many interconnected environmental insecurities that are destroying our planet. How then, can projects like PrevisAI be considered effective if the overall destruction of Earth's biodiversity is getting worse? This leads to the second, more general question *What is considered 'effectiveness' in sources of innovation in terms of sustainable development practices?* The problem with creating a measure to understand the impacts of innovation is that effectiveness is arbitrary. When goals and targets are misaligned between actors, there is a misalignment in what is considered successful implementation. This brings a challenge in translating ambitions between different levels of stakeholders in regard to the adequate implementation of sustainable development. The way that an idea or information is framed has an impact on the decision-making process. The meaning and knowledge of a certain innovation further impacts its application. This can be seen in the case of Artificial Intelligence. Since its initial creation, the knowledge implementation of AI has completely changed due to societal

circumstances. Further, while the concept has changed over the years, it also depends on which perspective is taken. While this analysis takes an environmental security perspective, in general, AI is not oriented towards environmental security and thus does not prioritize environmental measures in its design. This is then translated to the implementation of the technology and measuring the success of the technology in a certain circumstance.

Something to also consider is that Artificial Intelligence used to overcome environmental insecurities remains rooted in a purely quantitative form. However, qualitative dimensions of human life are subjective and will not always be able to be simulated in a quantitative form. This also applies to the understanding of the contribution of technical impacts because the conception of nature that unites empirical natural science and behavioural understanding of nature has been lost in more recent scientific studies; something which appears to be reinforced by Artificial Intelligence.

6.3 Technological Priorities in the Private Sector, the Leaders of the World

In today's economy, changes in technology are typically driven by the private sector. With the global drive to transition to a greener future, companies are beginning to orient their strategies towards a more sustainable outlook, or sponsoring development projects like seen in the case with Microsoft and Vale. Typically, the strategies that companies take can be split between two approaches: one, seeing new technology as a part of an existing business model that is driven by current market-demands, or two, an anticipation that the new technology will be a part of a new model within future market-demands (Lucht and van Tulder, 2019). There are risks within either approach, however the first of the two approaches, considered the 'old ways', or existing business models, falls to the risk of stagnation. Large companies seeking to adapt and 'reinvent' themselves, identify the political, economic, and technological circumstances and recognize the benefits that come with integrating sustainability. The implementation of sustainability into an organization's strategy considers sustainability as 'material,' whether it "can create value in the short, medium, or long term (Lucht and van Tulder, 2019)." Corporations then use a materiality assessment to identify the most pressing social and environmental issues to then incorporate sustainability into their business strategy (Borekar, 2022). Materiality assessments are typically left to the company to create and prioritize what they believe are the most pressing issues. The sustainable lens that materiality

assessments have, then shape the research, development, and implementation of new technology.

When implementing innovation that combats sustainability, the technological sector has different priorities and standards to uphold than that of other stakeholders. Companies hold their own priorities which are dependent on the individual companies values as well as the market standards. Economic incentives still drive the direction that research, development, and implementation of technology are taking. A critical problem for measuring sustainability is its transdisciplinary nature. In order to have a cross-industry innovation performance scale, there would need to be an agreed upon definition of sustainability. Due to the lack of consensus on a definition, no unified scale for sustainability has been created. Despite this, global companies trying to unify and standardize their sustainable measures have taken up the 2015 Sustainable Development Goals as a standard to uphold for sustainability. Some companies have taken the 17 SDG's and used them as a way to rethink their sustainable value creation. These companies use some of the more widely accepted standards for sustainable performance indicators including frameworks like the Global Reporting Initiative (GRI), Global Change Assessment Model (GCAM), WBSCSD Eco-Efficiency Metrics, and ISO 14000 XYZ (Gunarathe, 2019). However, even with the vocalization of creating new sustainable standards, most business models also answer to profitability and risk management and these measures continue to take precedence.

6.4 Emerging Technology and its Reorganization

The economic standards that our world falls under currently drive industry and technology. The emergence of bio-economy, or biobased economy, is a new model that "covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions, and principles (European Commission, 2018, p. 27)." Transforming the economy to a greener one, businesses are inclined to shift their business models to align with new competitive realities. Technological operations play a critical role in initiating that transition. New technologies including Big Data, Artificial Intelligence, biotechnology, drones, and satellites have the potential to increase environmental sustainability. The impacts of technological advancements in the 21st century can be seen through ICTs in which evidence is displayed through data sharing. However, while emerging technologies hold great potential, they are accelerating at a dramatic pace. In 2018 the United Nations Conference

on Trade and Development report stated that advances in emerging technology are driven by "(a) the cumulative nature of technological change; (b) the exponential nature of technologies such as microchips, which have doubled in power every two years for half a century; (c) the convergence of technologies into new combinations; (d) dramatic reductions in costs; (e) the emergence of digital "platforms of platforms" – most notably the Internet; and (f) declining entry costs (UNCTAD, 2018). With the speed at which these technologies are advancing there comes the threat of technology outpacing policymakers and society's ability to process change. Currently the efforts from local, regional, and international actors have been inadequate in harnessing the full potential of emerging technologies and achieving SDG's (UNCTAD, 2018). There is a divide in opportunities between developed and developing countries in science, technology, and innovation (STI), which can further perpetuate the inequalities existing between global North and South. "Success is dependent on the effectiveness of relevant innovation systems, which are weaker and more prone to systematic failures and deficiencies in developing countries (UNCTAD, 2018)." It is essential than, that there is collaboration amongst actors to facilitate a bridge between local knowledge and technology adoption. The need for a redirection of inclusivity has led to new approaches in innovation in which global policies are seeking to promote local groups in the innovation process.

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6.6 Conceptual Issue with Sustainable Development and the Lack of Voice of Indigenous Groups

It is interesting how different sectors describe similar values for the planet, yet the success of sustainable technology is not consistent. Bringing the issue further from just metrics, there is the problem with the systematic structure of sustainable development. The idea of sustainable development was created from Western-structured societies. The current structure is intertwined with capitalism and has an intrinsic way of thinking about the environment (Buckingham and Turner, 2008). Putting much of their beliefs in scientific rational, Western thinking is the hegemonic opinion in how the world works.

Capitalism driven by Western consumerism is the main source that is causing anthropogenic degradation. Due to this, the Global North has this obligatory perception that we are the ones who need to fix the problem. However, this leads to the solution being heavily influenced by the same Western-Scientific system that has expedited environmental degradation. So, the issue again lies deeper in the intrinsic nature of sustainable solutions. How then, do we as a society go about finding alternative solutions where joint collaboration utilizes

the skills and knowledge of every actor involved? How do we give the minorities most influenced by environmental degradation a voice?... especially when the technological advancements implemented allow for more global influence by the West.

The current sustainable practices in place either undermine or give limited power for change to indigenous groups such as those in the Brazilian Amazon. This is a core problem because it is the rich countries of the world that are the ones causing the problem, while the developing countries are the ones feeling all the negative repercussions. Alternative ways of understanding the environment are treated as second opinions. In the book Understanding Environmental Issues, the authors states "both indigenous and radical 'alternatives' are tolerated by Western society, which prides itself on this tolerance and its democracy, but are constructed as a minority interest with limited practical capability and, as such, can be effectively marginalized (Buckingham and Turner, 2008, pp. 15)." This can especially be seen in the way that technology is being strategized for amelioration of sustainable development. Western countries are trying to find alternative solutions through technology to combat climate crisis while simultaneously continuing to live in the same standards of living, working, consumption and travel. The problem with this is that once Western society creates one solution, it leads to more environmental problems. This can be seen with Artificial Intelligence. While AI has been reoriented to improve sustainable development there is an environmental cost in the research and development. Furthermore, not all the projects that AI is implemented into are prioritizing the environment.

In order to create significant and effective change, the voices of minorities are going to have to enter the centre of the conversation. Taking the example of the AI sector, there are already initiatives that go beyond just implementing AI into indigenous communities. Instead, these initiatives try to reorient the system to regard Indigenous Communities. One example that can be seen between creating a relationship between indigenous groups and AI is the CIFAR AI & Society Program. This program, found in communities across New Zealand, the Pacific Region, Australia, and North America offers a workshop that looks at AI through an Indigenous lens (Davidson, K, 2020). Considering Indigenous epistemology and technological practices, the team examines and assess a collection of texts to explore how the technology can be shaped to support those communities. The work findings from CIFAR's publication are something that could be implemented into Brazilian Amazon. While this is one example of integrating

Indigenous groups into the conversation, creating a resolution is going to take more than collaboration between stakeholders. Imazon's development projects, like many others, are examples in which multi-level stakeholders are working together to create sustainable practices. The latest technology is being implemented and used to make efficient environmental data, and yet, deforestation has reached its worst numbers in the Amazon this year. Real change is going to require a paradigm shift, one that does not prioritize capitalism and one in which the Western world is going to have to give something up.

7. Concluding Remarks

Today, the world is feeling the weight of the considerable damage that is being done through an interwoven list of practices and norms that Western societies' economy has brought upon us; some communities and places are feeling the consequences more than others. In the race to meet the living standards found in industrialized nations, developing countries often mismanage their environment in order to prioritize short-term needs instead of long-term sustainable solutions (Francesconi et al., 2015). Sustainable development is circumstantial: it depends on the time, space, and people involved. Trying to resolve multi-dimensional levels of security threats, sustainable development, and sustainable solutions are ambiguous in nature. That ambiguity trickles down to every part of the process of sustainability, including the implementation of innovation. With so many moving parts and actors involved, innovation implementation can have both positive and negative effects.

The aim of this dissertation was to analyse the impacts that innovation has on sustainable development practices and how those impacts are measured. To do this, the thesis analysed a crucial piece of emerging technology and its various implementations into certain social contextual situation. In an exploratory, comparative case of Artificial Intelligence, the first part of the analysis looked at the original understanding of AI and how its meaning has transitioned over time. The paper then explored the cases involving Artificial Intelligence in Imazon, a research institution focused on creating sustainable practices against deforestation. The area focused on was the Brazilian Amazon Rainforest and the security issue that the projects were aimed at mitigating was deforestation.

The first part of the literature review consisted of the theoretical security framework, which set out to explain the evolution of security studies and the way that security theories shaped

political and international relationships. Realism, the dominant approach, believes that the security of the state must be prioritized above all else. Following the Cold War and increased globalization, threats were no longer a one-dimensional phenomenon between states. More complex threats that transcended national borders began a new wave that started rethinking the term security. With a shift to more interconnected risks came a new field of conceptualizing security. Critical security securities arose as a new school of thought that expanded on the idea of how security was understood and who it should be targeted at. One theory under critical security studies is environmental security, a theory which considers security through the lens of the environment. Under environmental security, threats are no longer considered just in the context of the state. The referent object is dependent on whose security is in question, whether it is the state, the individual, or the biosphere. In short, the first part of the literature review set out to explain the security framework of the dissertation. In addition, it explained the importance of implementing the environment into the field of security.

With increased awareness of the global security threats that environmental degradation posed, the second part of the literature review gave insight into the responses from the global community. With the need for a solution came the introduction of sustainable development. Nations across the world came together and established treaties, policies, and action plans as a means to combat insecurities such as the rising temperatures of the Earth. Those measures included the Stockholm Conference, the 1972 Rio Conference, Kyoto Protocol, 2030 Agenda, 2015 Paris Agreement, and COP26. Throughout these global interventions, nations agreed that there was a need for joint collaboration. In 2015, governments established the 17 Sustainable Development Goals as global targets to drive sustainability. Since their establishment, these goals have been used as international measures by multiple stakeholders to restructure and re-establish their systematic frameworks to become more sustainable. While all the goals are interconnected, SDG Nine is specifically focused on innovation as a solution. The final section in the second part of the literature review went into the relationship between technology and human development, specifically looking into how sources of innovation have been used in the Amazon Rainforest to combat deforestation.

Since the literature review provided background on the security framework and the relationship humans have with technology, the next part of the dissertation explained the research question, methodology, and research design. This paper aimed to answer two

questions: what are the impacts of innovation in terms of sustainability; specifically, how have emerging technologies altered sustainable practices in relation to deforestation in the Amazon rainforest? And second, what is considered 'effectiveness' in sources of innovation in terms of sustainable development practices? Using a combination of a comparative and exploratory case study, the analysis sought to understand the original purpose of Artificial Intelligence as well as a case in which Artificial Intelligence is implemented as a tool against deforestation in the Brazilian Amazon Rainforest. Using the Social Construction of Technology framework, the paper aimed to analyse emerging technology through a socio-technical lens. The analysis of the original understanding of AI and current environmental implementations sought to show how AI has transformed as a concept as well as how it can shape sustainable practices.

The analysis led to a further, more general question of what is considered effectiveness. The research of Artificial Intelligence through the lens of the environment aimed to show that 'effective' implementation of sustainable technology is subjective. It does not only depend on who is being asked, but it also depends on the criterium of assessment: effectiveness can be talked about in terms of how smoothly the project runs, or if the overall outcome of the project is effective in achieving its goal. As seen in the case, Artificial Intelligence is being implemented and used effectively in development projects like those launched by Imazon. However, the environmental results are still negative, and the temperature of the Earth is still rising. Technology operations, research, and development aimed to improve sustainability and sustainable development projects continue to prioritize economic outputs. A reformulation model needs to be created that is not solely based on profit and economic gain, but rather one that supports the growth of sustainability. It will take a paradigm shift, one that prioritizes the environment, to begin the process of healing our Earth.

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