"When the wells dry up, we'll know the value of water"

How is A.I being used in water resource management?

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When the wells dry up, we'll know the value of water

ABSTRACT

This research delves into how A.I is being used in water resource management. Water problems such as scarcity, lack of sanitation, flooding and droughts are dangerous problems that pose a threat to humanity. Climate change and the gradual increase of temperature around the world accelerates the impact of the water crisis worldwide. Over the years, attempts have been made by organizations to utilize technology and artificial intelligence in a way that can tackle water problems. The gap in research that was identified was the lack of literature on the impacts that integrating A.I currently has and the implications it has for the sustainable development. This research conducted a qualitative content analysis of 40 documents from three different case studies: Banyan Water, Staal Instruments and HydroNET. The content analysis resulted in the identification of three themes: 1) usage of A.I, 2) financial considerations, 3) environmental concerns. A stakeholder analysis was also conducted to assess how different beneficiaries of A.I are being integrated for water resource management. The results of this thesis demonstrated that despite there being advantages for integrating technology to mitigate climate change effects this is stifled by the neoliberal market demands. These demands mandate that organizations focus on generating profit and thus the technology is framed in a cost saving instead of a means to achieve common good. Suggestions for further research include critically addressing the inequalities that exist due to capitalism which make integrating technology for common good a relatively difficult to task as not all stakeholders will be able to benefit from such innovations.

Table of Contents

Table of Contents

1. Introduction

The UNESCO highlights nine fundamental principles that make up water ethics. The principles are human dignity, participation, solidarity, human equality, common good, stewardship, transparency and universal access to information, inclusiveness and empowerment. These principles aim to provide a framework where nation states and business and organizations alike should approach water issues, because water is a necessity for everyone on earth. In order to work towards common good, the UN Development Program highlighted 17 sustainable development goals that they are aiming to achieve by 2030. To do so, the UNDP highlighted the ways that A.I could be used in different social domains, ranging from education to hunger, health, security, economic empowerment and water management. For example, after Hurricane Harvey in 2017 which devastated areas from flooding in Houston, Texas, A.I was deployed in order to combine satellite imagery with software which enabled the rescue workers to find alternative escape routes for those trapped (Chui et al, 2019). According to Cho, from the Earth Institute of Columbia University, A.I is a "game changer" in context of tackling climate change and understanding the environment, and has helped researchers predict 89-99% of natural disasters that would be difficult for humans to predict on their own (Cho, 2018). So, what is A.I? The term artificial intelligence was coined by John McCarthy in 1956 where he, along with other scientists, described it as "thinking machines" (Marr, 2018). According to the World Economic Forum, A.I refers to computer systems that can "sense their environment, think, learn and act in response to what they sense as well as their programmed objectives" (World Economic Forum, 2018). The Pacific Disaster Center, which has been operating for more than 20 years which aim to save lives and reduce disaster risk, has launched their own A.I initiative to tackle effects of climate change. The software, named DisasterAWARE aims to quickly and accurately provide government agencies and NGOs worldwide with data that they can use to protect vulnerable communities (PDC). To narrow down the research, the scope will focus on how A.I can be used in water management efforts.

It was in 1896 when Swedish scientist Svante Arrhenius foreshadowed negative impacts of the increased temperatures on earth. However, a lack of knowledge about the entire scope of climate change, mixed with political and commercial interests had humans living in blissful ignorance (Revkin, 2018). It is difficult to point out exactly when climate change activism began, however, in 1992 the UN Framework Convention on Climate Change was adopted, where a number of countries vowed to stabilize greenhouse gas and

carbon dioxide emissions as well as contribute to a sustainable future (UN, 1992). Climate change has affected our lives immensely in the past few years, and the changes that are happening to the world are deadly. According to Fresh Water Watch, only about 2.5% of the water on earth is fresh clean water, which means that we are living in a time where fresh water is becoming a scarce resource (2015). In the scope of climate change, increasing temperatures are causing water sources (rivers, lakes) to evaporate, thus leaving behind dry lands. Notably, in 2018 the world was shocked to hear of the high level water crisis that struck South Africa. Dubbed 'Day Zero', the world watched as the citizens of South Africa had to ration their water, and the government turning off taps in order to maintain water for as many people as possible (2018). The European Commission Emergency Coordination Center places the vast majority of Asia, parts of Northern and Southern Africa as well as parts of Europe and South America at a medium-high drought risk (ERCC, 2019). Over 40% of the world's population relies on agriculture as a main source of sustenance, thus climate change impacting droughts and water scarcity will impact (and is currently impacting) a high number of people (Climate Reality Project, 2016). The IUCN states that climate change manifests itself in changes in water patterns, and that is why we are seeing plenty of droughts, floods, melting glaciers, rising sea levels and so on. These impacts directly affect international water security as well as conflict due to water shortages and water problems (2011). All life forms on earth need water to survive, it is an essential part of our existence, and ensuring water security for everyone is vital.

One such example of the effect climate change has had on humans in recent years, is flooding. As the temperature of the earth increases, ice caps and glaciers across the world have also been melting, and the heat is causing the sea water to expand (Hancock, 2020). The consequence this holds for humans is increasing risks of flooding that by the year 2100, a study by Kulp & Strauss suggests, areas that are now home to over 200 million people will be permanently erased, due to rising sea levels (2019). Evidence presented from NASA demonstrated that the earth's rising temperatures have reached a level that is characterized as irreversible and that 2019 was the second hottest year on record, in all of human history. Many parts of the world are currently suffering droughts and famines, leaving many poor, working-class people to starve, sometimes to their deaths. The UN Department of Social Affairs published a study on social inequalities and how this affects how people face climate change effects. The report revealed that disadvantaged, and vulnerable peoples are less likely to survive, adapt or recover (Islam & Winkel, 2017). The report also revealed the differences in how better off individuals are able to survive or adapt to the effects of climate

change due to having access to, for example, sturdier foundations for homes in the face of floods. The Union of Concerned Scientists, which has been active for the last fifty years, routinely reaches out to schools, universities and governments in order to promote a safe, healthy and sustainable future. A report dating back to 2017 revealed that over 1,000 people have died in Southeast Asia due to flooding and landslides, which are relatively common to the region (Domonoske, 2017).

Such differences in quality of life required humans to look for efficient solution to mitigate the effects of climate change. One such solution appeared to be the integration of technology to increase the efficiency of the mitigation. A study by the American Academy for Social Work explored how harnessing modern technology could be an important step in working towards social good. The study highlighted that the world is rapidly producing large amounts of data as it progresses, yet it remains untapped for social good (Coulton et al, 2015). The study also discusses how the social sector does not currently benefit from the 'digital revolution', as opposed to other sectors, and how integrating it in ways that can help communities should be the main focus. While this addresses general social work, which includes providing access to water to communities, this is vital to consider as it exposes that the technology that although the technology is developed it the capabilities of the technology to do social good are not fully exhausted. A study by Holtgrewe & Werle discussed how open source technology would be a force for benefitting social movements in the future (2001). One of the things that the scholars argue for is the integration of open source and free software into society, as accessibility will allow for more social progress (Holtgrewe & Werle, 2001). This accessibility will allow for many different players to be included in the move towards progress, and increased participation would lead to increased engagement in movements towards social good. However, as the scholars point out, this needs to be critically assessed from the perspective of the economic systems that we live in. In this instance, the study pointed out that there is nothing that can inhibit businesses from commodifying such software which would hinder progress. Another study discussed the positive implications of technology oriented agreements between nations to address climate change (Coninck et al, 2008). This study largely revolved round the belief that technology could be a great tool to use to decrease particularly greenhouse gasses and fossil fuel emissions. The scholars affirm that technology oriented agreements among nations will yield positive results for tackling climate change. This demonstrates the effectiveness of technology as a tool to address this issue, however Coninck et al also emphasize that the

technology would need to be implemented alongside policies that would allow it to fully exhaust its potential in doing good (2008).

Using technology to mitigate the effects of climate change also proved to be useful in a study by Wilson et al. The scholars explored how using end use technology was very efficient in reducing emissions as well as providing a return on investment. However, the scholars found that this method was being marginalized and not fully utilize. This is despite the fact that as humans we are constantly developing and innovating new technology, but because they are not being diverted towards our needs, where they are predicted to be very successful, this causes a misaligned of priorities (Wilson et al, 2012). In modern times, investment in A.I technology has increased which indicates a shift towards a new method of addressing problems. A very recent study also explored the role that technology, artificial intelligence, in particular had to play with achieving the Sustainability Development Goals (SDGs) as posed by the UN, set to be achieved by 2030. According to this study, the integration of A.I would have a positive impact on 79% of the targets set by the UN across all of the SDGs, and would negatively affect them by 35%. In particular, the study demonstrated that the 'environmental' sector of the SDGs would benefit 85% from artificial intelligence, with a 12% negative projected impact (Vinuesa et al, 2020). This further demonstrates the scholarly perspective on positive impact that utilizing technology can have on tackling climate change. Technology also offers special 'affordances' to humans that greatly benefit us. The affordances theory was first created by James. J Gibson who talked about affordances as a way to measure what the environment offers the animal and what it provides, good or bad (Gibson, 1977). In the context of this research which revolves around technology, Mettler et al discuss how the theory of affordances has come to evolve and include technology appropriation process and the relationship with human agency and interdependency on technology (2017). The fear of technological determination is also discussed in the article, and it is one of the main ethical concerns that individuals have because of the unknown that comes along with using such powerful technologies. In their article, the scholars study how adding robot service in hospitals would impact people's perceptions and it turned out that most individuals thought humans were more reliable than robots at the end (Mettler et al, 2017). This finding is interesting as it provides a perspective on how humans are thinking about the future and their role in it. Affordance theory provides value to the research surrounding using A.I to tackle the water crisis because it allows for a deeper analysis on the relationships between humans and technology.

There are always ethical considerations to be kept in mind when discussing integrating powerful and smart software into our daily lives. A study by Floridi et al assess the ways that A.I can be used or misused by humans, where they are framed as risks vs opportunities. For starters, the opportunities lie in enabling human self-realization, enhancing human agency, increasing societal capabilities and cultivating societal cohesion. The risks lie in devaluing human skills, removing human responsibilities, reducing human control and eroding human self-determination (2018). Attempting to balance the risks and opportunities of integrating AI, while dealing public backlash is a difficult task, the House of Lords select committee on A.I discussed this, referring to the opportunities that A.I provides for progress in the country, but mentioned dealing with public backlash against genetically modified crops, for example (House of Lords: Select Committee on Artificial Intelligence, 2017). Keeping in mind the fast-paced nature of technological advancements coupled up with political climate worldwide, it further adds to the struggles of integrating A.I into our daily lives. Fears that malicious acts by humans such as scammers, hackers and possibilities of cyber-warfare can accelerate with A.I are rampant (Taddeo, 2018). These fears are valid as they can impact the rate at which we are able to integrate A.I into our societies, businesses and everyday life. Increasing fears regarding A.I exceeding human intelligence and consequently take over jobs may also be contributing factors as to why humans can be hesitant to integrate it to its full potential (Pandey & Axios, 2019). Seeing as water is such a vital resource, ethical consideration must be made when it comes to water management.

In response to the rise of discourse surrounding climate change, many businesses have developed sustainability initiatives. In Australia, the Python program has been implemented, whereby the software surfs through historical data and provides efficient techniques where the Melbourne Water authority utilize it in water treatment plants. The decreased electricity costs and increased efficiency aim to be able to provide more water for the residents of Melbourne. (Wells, 2018). Furthermore, a study by Lin et al argues that by using Block chain technology to decentralize public water transaction records, and A.I to run fast, small scale scientific experiments as well as identifying shifts in water distribution can help in measures towards water resource management (Lin et al, 2018). Silo, who define themselves as a network of scientists who build AI for people, developed a software which optimizes water treatment. This initiative aims to provide cleaner water at a faster rate, and lower prince. (Alanen, 2019). In China, in collaboration with IBM, a cloud based A.I system helps the country better manage its water management by providing intelligent

oversight of China's bodies of water. The technology also helped in decreasing management costs by 40% and is further developing the software to relieve manual labor.

According to an Intel study which explored how decision-makers in businesses feel about using technology to fight environmental problems, 74% of respondents agreed that technology is the way forward. Intel has committed to restoring 100% of their global water use by 2025, and have funded projects across the United States which they believe will help them achieve 56% of their goal (Brady, 2018). This progress from a prominent company demonstrates the direction tech companies are moving towards. Despite this, referring back to the example of flooding in Southeast Asia, the NPR report stated that the level of flooding in particular could be reduced or contained, except for the fact that the governments of the countries affected do not have the correct resources, such as enough capital to provide safety for their citizens. (Domonoske, 2017). Thus, does A.I really provide a useful solution, in this case? A.I is a fascinating technology that indeed can be used to make the world a better place in terms of helping humans find solutions to combat chronic problems like climate change. However, it is still important to acknowledge that A.I is not the only solution, and it is important to evaluate the overall effectiveness of implementing A.I in order to help with climate change. Most importantly, climate change is very much caused by human action (weak regulation, low commitment to changing energy consumption models, over consumption, wasteful cultural practices etc.) and yet we speak about the solution in technological terms thereby deflecting from the real changes that need to be done where AI is just one part of this complex human centric solution.

In an article adapted from Dayal, Deo, and Apan's book the authors discuss the way that artificial intelligence can be used in Australia for drought mapping. As the climate gets warmer each year, droughts are becoming a real threat for many farmers across the world (2017). The authors believe that using artificial intelligence and neutral network algorithms, experts can predict instances of prolonged droughts, which can help in conserving water so that people do not have to run out or lose access to water in times where they need it. The reason this is vital is that it calls for the advancement and acceptance of new measures to fight the effects climate change is having on communities, in this case specifically farming and agriculture as droughts impact them heavily (Dayal et al, 2017). Furthermore, in Oman, researchers found that by implementing A.I techniques and data mining, they were able to improve the ability to enhance the performance of river reservoirs. The researchers were able to create water reservoir forecast charts that demonstrated how water reservoir inflow changed due to climate change, and how they can adapt to the changes in order to maintain

the reservoirs (Yang et al, 2017). Additionally, in Oman, research has been done to explore simulation based water management system, which aims to optimize and evaluate irrigation practices in the country due to problems with saltwater intrusion. The research showed that the simulation based optimization did yield useful and tangible results for the Sultanate, however, the set-backs were found in the objectives of the optimization. Profit based objectives were deemed not sustainable in the long term, however, a multi objective optimization using the software was said to have the best outcome (Grundmann et al, 2012). This was an interesting finding because the research reveals that although A.I integration can help with managing the water system in Oman, other factors such as the objectives of using the software also impact the overall effectiveness of the practice. Another criticism from Jaffe, Newell & Stavins suggests that decisions to advance technology are largely shaped and affected by market demand. The scholars argue that the value of implementing such technologies have to first be complimented by economic incentives which govern the logic by which these technologies are created (2005). The study takes a very critical perspective on the integration of technology for environmental policy because, according to the scholars, there is a lack of strong environmental policies in nations worldwide make it difficult for there to be any incentive for organizations to invest in technology that will address the whole problem. This issue is relevant for this thesis because it highlights an important perspective that is the market in which these technological innovations operate. This suggestion will be relevant when investigating how A.I is currently implemented in organizations that claim to offer solutions to water resource management.

There lies a scholarly gap that this thesis aims to address. Despite there being general literature regarding the use of technology to mitigate climate change effects or resource management, there is not enough literature that analyses the manner in which A.I is being implemented in organizations and how this implementation is framed. As time progresses, studies have become more optimistic about the usage of technology as it has become clearer that it can provide a new method of efficiency. In order to successfully understand if technology is going to revolutionize human's response to climate change, then an analysis on how it is currently being used and how its usage is being framed must be done. This will help to gain a deeper consideration as to who is benefitting from this technology, and in what ways. Therefore, this thesis will focus on answering the question: How is A.I being used in water resource management? This question was answered by exploring how artificial intelligence was being positioned by organizations to address the water crisis. Furthermore,

another element that was analyzed was looking at who the stakeholders were and how they are positioned in organizations.

2. Theoretical Framework

In order to gain a deeper level of perspective and knowledge about the crisis and the usage of technology, this literature review will discuss previous research that was conducted in these areas, in three sections. The first section will revolve around the water crisis and will explore previous literature surrounding water problems and climate change and how technology has the capability to intercept. The second section addresses the neo-liberal approach towards tackling water issues and water resource management. The third section of this literature review is a review of literature concerning A.I being used in sustainable development initiatives.

2.1 Water Crisis

In 2018, Cape Town in South Africa became one of the first major cities in the world to have to turn off its taps. This was groundbreaking and became a real eye-opener for scholars and water management experts alike into exploring in depth the water crisis that the world faces, in the present time, and also in the future. Of all water on earth, only about 0.3% can be used for human consumption, leaving more than 700 million citizens suffering from water stress, and scarcity. UNICEF estimates that by 2040, one in four under the age of 18 will not have access to clean water (UNICEF, 2017), and the UN reports regarding the water crisis report figures of up to 2.2 billion people do not currently have access to safe drinking water (UN, 2019). Water problems, namely polluted water sources are also leading causes of diseases, like cholera, in countries lacking the infrastructure to provide clean water. Climate change also contributes to water problems and shortages in a myriad of different ways, around the world. For example, a study analysed the effects of climate change on water resources in Central Asia. The study, by Yang et al, discussed that in previous research, a consensus has been reached that the temperature rise in Central Asia is occurring rapidly and is affecting the region. The scholars found that despite the water being the key to sustainable development in the region, climate change is causing drought due to higher evaporation, as well as the melting of glaciers in mountainous areas (Yang et al, 2019). The region has seen a 3-7 degree rise in temperature over the past years, and this has had an impact on the agriculture industry as many people rely on that for necessities and income. It is important to understand the direct social issues that climate change causes as well in order to assess whether or not the solutions can be seen as viable, sustainable options

in the long run. Moreover, agreements made between the Central Asian countries set to move towards the development of the region are in danger of not being fulfilled due to climate change (Yang et al, 2019). Water management should be based on hydrographic borders and ministries should be able to make timely decisions without political intervention. The scholars mention that through their analysis, they found that fully-integrated management of water resources, is essential in Central Asia and that the looming crisis due to climate change should provide motivation to find water management solutions throughout the region (Yang et al, 2019). Another study also analysed the impacts of climate change on China, one of the world's largest countries and emission's producers and found that climate change's effects on the water will impact the agricultural sector, which is vital for the country (Piao et al, 2010). The scholars cite that the country has already experienced droughts and flooding in its history, however, increased temperatures which can lead to droughts as well as glacier melting places uncertainty on water professionals. More recent studies regarding climate change in China demonstrate that climate change is impacting the agricultural sector, which will suffer greatly due to the impacts that climate change will have on water (Yang et al, 2016). Technology has a role to play in mitigating the effects of climate change and the water crisis on these nations. In an article by Peine and Herrmann, the scholars discuss how innovations need to be designed to be able to address social problems and changes in their environment (2012). Furthermore, the Organization for Economic Co-operation and Development released a report that promotes the use of technology to address societal challenges. This further indicates that technology is being referenced in literature and public organizations as a means that can benefit society and help tackle problems and crisis.

For a more humanized demonstration of what the previous statistics truly mean in a real-world application, it is only necessary to observe how water access plays a key role in most large-scale humanitarian crises. For example, the Moria refugee camp on the Greek island of Lesvos accommodates over 20,000 people which remain enclosed in living conditions where access to clean water is virtually non-existent. Even the natural canals that ran through these areas have been overrun with plastic waste from the camps, due to poor sanitation management from the Greek authorities. Facing the spread of COVID-19, the extremely limited access to clean water and sanitation products can lead to a massive outbreak of disease (HRW, 2020). Not far from Greece, the Iraqi city of Basra has faced a severe societal and economic downturn as her main river, the Shatt al-Arab, has become exponentially more contaminated over the course of the last decade. Once a booming port

city with an importance to rival that of Baghdad's, it lacks the capacity to properly process the waters of the river, endangering the water security of about 4 million people (Reuters, 2019). It is important to also emphasize regions that are dealing with water management crises, even in places where there shouldn't be. A glaring representation is the placement of Venezuela as number 11 on the list of countries with the most natural available freshwater, with 1,233 cubic kilometres of it, but where 8 out of 10 citizens do not have regular access to clean water for sanitation and consumption (CSIS, 2019).

In the present time, water challenges are especially worrisome as rising populations worldwide demand clean, abundant supplies of water to sustain them and major issues such as climate change are placing a great strain on the water industry to keep up with those demands. Climate change limits the availability and quality of water resources, due to the risk of environmental disasters such as droughts and water shortage, as well as floods and intense storms. It is essential to understand that the connection between clean freshwater supplies, our society, and the environment are all inextricably linked. The failure to manage our consumption and distribution of natural water resources have dramatically affected drought conditions around the world, endemic disease outbreaks and the sovereign rights of people all over the global south. Mass exploitation of rivers and lakes have also brought to the table the destruction of ecosystems essential for human survival as well. Essentially the societal and environmental impact of water mismanagement is a multifaceted, complicated and an incredible diverse problem that is looming over us. Not every problem related to water management is a direct result of human actions, but can certainly aggravate situations. La Niña and El Niño, both were natural occurrences that affect flooding and drought conditions around the southern hemisphere, in part by temperature shifts in ocean water (NOAA, 2020). The wide range of challenges regarding water management in our environment and societies is of utmost importance to most humanitarian efforts globally, and therefore, it is vital that a sustainable solution be found to ensure water is available to everyone. A study was performed on the way that technology impacted conflicts when it was implemented near the Andean Glaciers. The study details how after technology was integrated in the region, various stakeholders from all background (farmers, land owners, workers) were managing the water differently based on their priorities and this caused a conflict. What this illustrates is that because this technology was designed using a neoliberal perspective, and so it automatically shifts the power dynamics between the stakeholders in question (Carey, French & O'Brein, 2012). For this thesis, it's important to consider how this will also be reflected in the case studies that were analyzed because that provides an

insight into how truly successful the technology is. If it is truly a way to achieve 'common good', then it will not yield conflict, it will do the opposite and make sure communities standard of living improves and everyone has equal access.

This is important to note for this research because to answer the question of how A.I is being used for water resource management, it's vital to have an understanding of the extent that water problems affect large portions of the global population and how power dynamics and neoliberal logic affects that. It provides a wider perspective for just how essential technology can be to improve human life, and allows for a critical review of how the technology is currently used versus it's full potential to help humans all over the world. The literature illustrates that many people across the world are suffering because of water problems, and thus, while conducting the data analysis, the knowledge of this will be useful in operationalizing concepts to look for in the data sets.

2.2 Neoliberal approach to water management and its problems

Despite climate change and its effects, scholarly reports also compare the ways humans intervene with natural resources and can also have an effect on water. Haddeland et al discuss how in river basins, man-made dams and water withdrawals altered the natural water cycles (2016). In turn, this affects the annual water runoff of the river and can have a higher impact on the rivers than climate change, causing uncertainty and scarcity. Yan et al also discuss the ways individual consumption and demand has greatly contributed to the water issues facing the region (Yan et al, 2019). This is vital to consider when analysing solutions to water management issues, as man-made contributions to climate change have a large effect that may continue to cause damage. In her book, *Privatization of Water,* Karen Baker explores how the consequent capitalization of the resource is one of the main reasons that water is not equally distributed around the world (Bakker, 2010). Bakker provides an example of an unnamed British water company which caused an uproar in London in 1995, during the droughts. The company conducted a large scale water redistribution journey, moving water from lowland streams to their own private reservoirs. The public protested the increased price of water bills, and the unfair control a company has on the redistribution of water sources and demanded the government give back control of the water supplies in the country (Bakker, 2010). The scholar offers a relevant perspective regarding why we struggle with water problems, ten years later. Bottled water has become an extremely sought after commodity that grew in demand globally. FIJI Water, a California based water supplier, is

one example of a company that has garnered attention and a reputation around its so-called 'taste of a paradise' product. Years after the company's success, they have been in the midst of several scandals which revolve around the misuse of the resources, namely water and land, on the island of Fiji. The company has created an uncomfortable atmosphere in the island - despite having the responsibility to utilize the local workforce, Fiji Water opts to outsource white-collar jobs and thus damages the labour market of the local people, many of whom relied on the company for employment (Jones et at, 2017). In the case of Malaysia, scholar Jeff Tan analyses the failure of the water privatization system in the country and why they were allowed to proceed, despite major pitfalls (Tan, 2013). The failures of the private sector were their lack of investments into the water systems in Malaysia, consequently creating an inefficient system. Tan identified three problems which contributed to the failure and the consequent renationalization of water resources, firstly, the ongoing public sector financing, secondly, selective private investments, or "cherry-picking" and lastly, inconclusive efficient gains (Tan, 2013). The privatization of water, a natural resource is therefore discussed as an issue in literature due to its negative effects, namely the consequent inaccessibility of good quality water. Interestingly we are facing this more strongly than ever before as the COVID-19 crisis may demand a serious overhaul of the neoliberal and market approach to critical public resources as a moral and ethical choice. This ties into the process of commercializing and commodifying technology that will be used to help with water resource management. There needs to be transparency from organizations that are offering this technology regarding the logic that is being taken into account while designing the technologies themselves which will help us understand if these technologies are in sync with common good principles. Currently, during the pandemic, we are facing a global lack of access to crucial resources such as medicines, tests and protective equipment has showcased the severe limitations of the market logic upon these critical resources. The situation, however, is seldom related directly to scarcity but to factors such as the lack of political will and the financial ability to provide adequate facilities that are affordable for the users. Many of the fast-growing urban and industrial areas in the developing world are facing water challenges similar to industrialized countries (protection of the quality of surface- and groundwaters) without having the means to satisfy even the very basic water needs (access to adequate water and sanitation facilities) (Zehner et al, 2003). The book *Greening Criminology in the 21st Century* discusses the, in the author's perspective, criminal ways that water privatization has affected water management. The book demonstrates the ways that corporations have a monopoly on water resources, thus creating an environment where

poor governance and a lack of commitment from corporations towards the public creates water scarcity (Hall et al, 2016). The commercialization of technology is also a factor that leads to poor results, this is because metrics are not defined by the good that the 'commodity', which in this case is technology, can offer but it revolves around profit. A good example of this is how the notion of 'sustainability' was co-opted and commercialized. The word sustainability has become almost a cliché, a word that corporates, governments and educational institutes emphasize the importance of. According to Fuller, to give more meaning to sustainability, the word can be theorized by four dimensions. Futurity, which refers to the concern for future generations, environment, which refers to the protection of the integrity of the ecosystem, participation, which refers to how people participate in decisions that affect them and lastly, equity which refers to the concern of poor and disadvantaged communities (2010). Furthermore, a study by Curtis and Reddy provided an exploration of how sustainability has become a branding tool for many organizations (Curtis & Reddy 2017). This thesis, which is written in the perspective of marketeers highlights the three challenges that marketers face currently in regards to sustainability. The three issues that were highlighted are 1) creating a competitive advantage, 2) building trust and loyalty with the customer base, and 3) development of opportunities within the market. What this demonstrates is how willing organizations are to promote the idea of sustainability as it serves a commercial purpose. Therefore, organizations utilize the word sustainability in order to create a brand image of the product they are selling, which exemplifies how commercialized the word has gotten in recent years (Curtis & Reddy, 2017). This framework allows for a more concrete analysis of sustainability and how it is implemented to supposedly do good and will be used for analyzing the case studies. This is because, as previously mentioned, the word sustainability has become a cliché, a buzzword, and more people are starting to be more critical of how certain companies use the word sustainable because it is being used for commercial purposes. One such example of using the idea of sustainability for commercial use is Tesla. The company has come under scrutiny for its 'clean' label, especially with regards to the battery production (Ellsmoor, 2019). A report by the International Council of Clean Transportation revealed that the countries in which the batteries are produced, as well the battery composition contribute greatly towards gas emissions (Hail & Lutsey, 2018). Research that was done concerning the implications neoliberal approaches can have on sustainability suggested that neoliberal values often overshadow the requirements and principles of sustainability and therefore it does not yield the results that it should have, which was to achieve common good (Baldwin et al, 2019).

Yang et al's study explored the stakeholder role in water allocation, where they identified three main groups that can be affected in the context of a water shortage (2016). The groups were key players which included government entities which have high influence and high interest in maintaining water resources. Secondly, the scholars identified the subjects, who are individuals with high interest and low influence such as municipal governments and local communities, and finally, the last stakeholder group identified were crowds which refer to people with low influence and low interest (2016). Stakeholder analysis provides a perspective of the different individuals that will be impacted, and this is important to keep in mind when searching for solutions as they should be able to help everyone.

An article by Mikler & Harrison explored how capitalist innovations can help mitigate climate change effects. The authors analyzed liberal market economies and coordinated market economies. Liberal market economies are identified as the ones who will have a difficulty in achieving success with implementing technology for climate change mitigation. This is because countries, like the United States, that operate with liberal market economies prioritize short term profits as opposed to continuous, long term investment from the government in such innovations (Miklet & Harrison, 2012). Identifying the way privatization of water contributes to scarcity, inaccessibility and water management issues is relevant when it comes to offering solutions for water management. This is because the solutions should optimally work for everyone, and it is important to understand the different stakeholders that may affect how the water management solutions would function in practice. Having an understanding of the neoliberal approach to water management can provide a deeper understanding of the systematic inequalities that people worldwide are facing. Furthermore, understanding how stakeholders are affected by the policies that are taken into account while designing the technologies is important to learn how these will eventually create common good.

2.3 A.I for sustainable development

Machine learning artificial intelligence technology is in the process of testing to ensure it can become a possible solution to water resource management. Scholars have long discussed the impact that artificial intelligence could have on the world in general. A study by Makridakis revealed that A.I is developing rapidly and is encroaching on our daily lives. When we use Siri, Alexa, online chatbots, rely on algorithms, we are utilizing artificial intelligence technology, and this trend will only increase in the next decades (Makridakis,

2017). The scholar likens the rise of A.I to the digital revolution, which would make it intrinsically linked to our daily activities. However, when it comes to integrating new technologies there are always discussions to be had with regards to the readiness for such technology, which may seem invasive at first. For this reason, Makridakis points out two groups, the "pessimists", who are uncomfortable with a future filled with artificial intelligence technologies, fearing a dystopian universe where the machines would out-smart humans. The second group, the "optimists" are individuals who believe that we can accept our limitations as human beings and allow for smart technology to help us and improve our reality (Makridakis, 2017). In a study that discusses the role of A.I in achieving the UN Sustainability Development Goals, the authors touch upon working towards sustainable development with artificial intelligence. The authors discussed how the 'wealth' that will be generated as a result of using A.I to develop sustainable solutions to societal issues, like the water crisis, may result in even more inequality (Venuesa et al, 2020). This, according to the scholars, is due to the already existing inequalities in education and computing around the world. The most capable nations and people who already have access to this will just have more access, and thus even if the A.I can enable progress – it will not be equal and thus will not yield common good. Another issue that was pointed out was that pre-exisitng biases play a large role in how people develop the machine learning technology. If these biases were to be integrated into the artificial intelligence, how would that yield public good? This is an issue that will also be explored in this thesis during the analysis as it relates to the stakeholders and how various stakeholders are impacted as result of this bias and inequality. Finally, the study also points out a limitation when it comes to using A.I for sustainable development and that is the problems that arise from politics and how that may affect how end users can be influenced. The scholars discuss how propaganda can be easily spread through A.I technology at the hands of the people who create it, this could lead to more polarization in the world and thus would not serve its intended purpose (Venuesa et al, 2020).

Debates regarding the ethics of A.I are in full force currently, as Taddeo & Floridi discuss in their study, especially on the delegation and responsibility with regards to integrating A.I in our daily lives. A. I can benefit our lives by delegating difficult tasks to the technology and lowering costs, increasing reliability and offering flexibility in use. However, this may also have a negative side effect, for example, the scandal surrounding COMPAS, a legal AI firm which discriminated against African American males, due to the programming, and thus making it vital to assign a great level of responsibility to individuals

to develop these technologies (Taddeo & Floridi, 2018). The concepts of invisibility and influence were also brought up, where the scholars discuss how when A.I develops further, it is able to become an invisible factor which facilitates daily life, as estimates reveal that by 2022, 55% of houses will have a home assistant like Amazon Alexa installed. This may bring up issues of privacy and transparency, as we must determine how much invisible influence we give to A.I (Taddeo & Floridi, 2018). In the case of water resource management, there is currently research underway to promote usage of technology to work towards water resource management. For example, Smart Water Quality Monitoring Systems or SWQMS were implemented in the island of Fiji, and analysis of this system was performed in order to examine if it is fit to implement throughout the islands in the Pacific. In short, the SWQMS works in such a way that it collects real-time data into a "cloud", which can be accessed by the relevant public entities. (Mamun et al, 2019). The study revealed that this system was capable of delivering accurate and consistent information regarding the water supply in real-time, and thus would be an appropriate method to implement in the pacific to help with water resource management. Another study analysed the effects of System Dynamics in Singapore, where the population is rising and demand for water is as well. System Dynamics allows for the study of complex network systems and was helpful in tracking economic growth, business development as well as water and resources management (Xi & Poh, 2013). The scholars ran an analysis of their own SD named 'SingaporeWater' and found that using the system allowed them to see that Singapore needs to invest in better water infrastructure to maintain the needs of the population. This study demonstrates how A.I technology and smart technology help in providing accurate information that helps countries with water management. Another example of studies that pertain to A.I usage in helping countries manage water, is how predictive analytics were used to gather information about water pump operations, water quality and water quantity (Bejarano et al, 2018). The studies surrounding the usage of A.I in water management provide a base to examine what has been done before, and what were the outcomes. This is useful in the analysis of current or future A.I solutions to water management. While it's vital to understand how the previous studies discuss A.I solutions for water management, there is a gap identified and that is how the A.I is being implemented and for whom. The research that has been previously done serves to provide examples of the A.I being used in water management, but it does not delve deeper into a critical perspective of the different ways this technology is being implemented in society. This research aims to provide a critical approach to thinking about how A.I can be integrated worldwide to help

with water resource management. Therefore, the factors that hinder sustainable development such as effects of neoliberal logic, inaccessibility, and inequality play a large role in how the analysis will take place.

3. Methodology

In order to answer the general research question "how is A.I being used in water resource management?" this thesis explored how A.I is currently being used to provide solutions for water management. To conduct the research, qualitative content analysis of three case studies will be the method of choice. The research combined the analysis of case studies as well as stakeholder analysis of companies that offer A.I solutions for water management. The qualitative case study approach allowed the analysis of a specific phenomenon within its context by utilizing various data resources. A case study, according to Baxer & Jack (2003) should be considered when: a) it should aim to answer whether a how or why question, b) you cannot manipulate the context of the case study, c) you need to cover contextual conditions that are believed to be relevant to the phenomenon under the study, or d) the boundaries are not clear between the phenomenon and the context. For this particular study, the case study approach is fitting because it aims to answer a 'how' to a situation where the phenomenon (A.I) and the context (water management) do not have clear, and established boundaries. Through the usage of case studies, analysis of current efforts by A.I firms to provide solutions that will help with water management will be made and afterwards, a framework will be offered based on the analysis which will demonstrate how A.I can be used in water management initiatives. The sampling method chosen was purposive sampling. Purposive sampling uses personal judgement to asses which cases can be the most helpful, and in this research, three cases were selected as they were deemed suitable for the research (Dudovskiy, 2008).

The data will be collected through a content analysis, where the overall content on the websites of the case studies will be looked at. The research will look for patterns within the three case studies, and will use those patterns to create different themes. Those themes will then be helpful in answering the research question which will explain how A.I is being used for water management. Furthermore, a stakeholder analysis of all three industries will be performed. This analysis will aim to see where A.I is positioned and the solutions it offers, and will be placed against what the experts in the areas consider the most pressing problems to solve. This will be important in providing a holistic critical analysis which will display the extent that A.I can be used as a tool for combating climate change. The data and patterns

collected on the websites will be organized into codes. The first set will be general, and will include all relevant information found on each website through the analysis. Afterwards, the set of data will be put in categories where they align with other data to create categories. The categories will then be used to create the themes that will answer how A.I is being used in water management.

This research will aim to provide a holistic analysis of the extent that A.I software is providing solutions for water management problems that are caused by climate change. This research aimed to shed light on the consequences of climate change in respect to water problems and water management, and to explore how A.I can be possible solution to the problem. This research also aims to contribute to scientific research by providing an analytical perspective on A.I initiatives and by providing a guideline whereby future research and businesses can follow to understand the possible shortcomings of A.I, as well the way it can be used to benefit humans at a large scale. It is vital to acknowledge the human fault in creating and propagating the problem of climate change in order to shed light on the urgency of the problems we are facing, and water is one of the main problems that can send the entire world into panic Furthermore, this research aimed to provide a critical perspective on stakeholder's interests, and how that can impact whether or not an initiative can be used for collective good.

The literature demonstrated that water problems are posing a great threat to humanity. It also exemplified the ways that external factors such climate change and human intervention with neoliberal markets worsen the situation with the water crisis. The literature also pointed out that as we are living in a fast-paced era of technological advances, throughout the year's experts have found different ways that artificial intelligence can facilitate water resource management. Therefore, this thesis explored how AI being positioned in addressing the water crisis and to what degree can this lead to sustainable development. The thesis aimed to do so by also analyzing the stakeholders and how they are positioned, as well as how the A.I is framed as the solution to the water crisis.

To do so, the research will be conducted on three organizations that offer water management solutions using A.I for water management. A total of 40 texts extracted from the webpages of these organizations was analysed. First, the Dutch organization HydroNET which uses information and communication technology (ICT) to enhance water resource management. The organisation provides water management solutions that tackle droughts, floods, urban water management, water quality management and agricultural water management. Although Dutch, the organization's platform is operational in South Africa,

Germany and Australia. The international aspect of this organization can provide a means for analysing how water management is used in different parts of the world. Second, the American organization Banyan Water will be looked at. The organization uses cloud-based software to collect water data and analytics in order to help save water for its stakeholders. Banyan Water operates from Austin, Texas and serves an international market. Finally, Staal Instruments is the third organization that was used as a case study for this research. Staal Instruments is a Dutch organization that facilitates water and wastewater management through real-time monitoring and analysis through radar software. Though based in the Netherlands, Staal Instrument's has customers throughout Europe, Asia and America.

Choice of method

In order to perform the analysis, the chosen method for this research study was qualitative content analysis. The content analysis was conducted on 40 webpages in total, and they included 20 pages from Banyan Water, 12 pages from HydroNET, and 8 pages from Staal Instruments. Qualitative methods of analysis are effective for performing exploratory analysis of certain phenomena. In the case of this research, the qualitative approach allowed for a deeper, critical analysis of the data which is what this research aimed to do. Qualitative content analysis was also chosen for this research because content analysis allows for the interpretation of the meaning and relationships between texts and the organizations intentions. These observations and interpretations were used to create themes that were useful in identifying answers to the research question of how A.I is used in water resource management. Scholars Hseih and Shannon describe three methods of content analysis: conventional, directed and summative. This research took the approach of a directed content analysis whereby there is preexisting information and literature regarding the phenomenon that is being explored, which is A.I in this case, but there are gaps present, such as critical analysis on how A.I is actually being used and marketed in organizations and if that will result in benefitting a mass population. Furthermore, a directed content analysis approach takes into account preconceived ideas and theory regarding the analysis, so the categories that are created are not purely extracted from the text, as it would be from conventional analysis (Hsieh & Shannon, 2005). For this research, a number of themes were highlighted prior to the data analysis process, and that served to place the analysis in a certain scope that helped to answer the research question. The content analysis was done through color coding the raw data sheets and then placing the data into a coding frame, which can be found in Appendix 2. The color coding provided a code system for which each color represented a theme that was identified. This made the data analysis procedure longer

than it would have been if software was used, such as Atlas.ti, however due to technical problems, color coding was used and allowed for a clear indication of the themes within the data sets, for demonstration please see Appendix 1.

Sampling and data sets

The sampling method chosen was purposive sampling, which is a method of sampling whereby the researchers uses previous knowledge to decisively choose a sample for the study. (Dudovskiy, 2008). Purposive sampling entails the researcher choosing nonrandom data sets for analysis based on an informed background on the research question(s) (Etikan, Musa & Alkassim, 2016). Purposive sampling also entails that the data sets that are chosen for analysis have value that is pre-determined by the researcher from previous research.

For this thesis, the case studies that were analyzed were major projects that have real life impacts and rich stakeholder mappings. This is because they offer an insight on how privately owned initiatives interact with the notion of promoting public good. Thus, these case studies provided a lens on how the impact that neoliberal approach to addressing societal problems and whether or not it can actually promote sustainable development.

As per the research guidelines provided, the data sets for text based analysis should have a minimum of 300 words. Thus, to stay in line with the guidelines, this was taken into account when choosing the data sets for this research. Furthermore, the content of the web pages was important. For example, articles and PR posts regarding COVID-19 updates or internal news regarding company updates (i.e: new staff member, new location for office) was excluded as it lacked relevance for this research.

In order to conduct qualitative content analysis, the following themes were identified as ones that may help organize a group of ideas. This is important in qualitative content analysis, as the data sets can be vast and so narrowing down themes allows the research to be narrowed down towards relevant topics. (Vaismoradi et al, 2013). They were the following: a) sustainability, b) water issues, c) neoliberal logic, d) technology & software affordances. These themes were chosen due to the literature background that was taken into account while performing research prior to analyzing the data. Sustainability was identified because this thesis aimed to explore if A.I can be integrated in order to achieve sustainable development in the future. This theme was informed based on the literature surrounding sustainability and sustainable development using technology. For example, the notions of sustainability and commodification of it as a marketing tool as mentioned in Curtis and Reddy's article inspired this theme. Moreover, Fuller's four dimensions of sustainability also

23

inspired the creation of the theme because it allows for critical assessment of how the organizations frame sustainability. Water issues was identified as a theme because it is the central issue that the A.I in the case studies is attempting to solve. Analyzing how water issues are framed in the case studies can provide insights on which stakeholders are benefitting from the technology that will help them overcome water issues. Furthermore, it also showcases which stakeholders are in need of technology, and require this technology to help them overcome the water issues. The literature revolving around how water crisis and climate change is wreaking havoc around the world inspired this, because it allowed the research to be critical of how the organizations addressed these existing issues. The framing of water issues is important because it provides a perspective on what the organizations priorities are. In general, it is essential to take an in-depth look into how water issues are framed, and how A.I is the solution to combat those issues. Neoliberal logic was looked at while analyzing the data as well, this stems from the literature that has offered critique on how the commercialization and commodification of technology creates tension and inequality. This theme was formed due to the critical literature that surrounds the usage of neoliberal and capitalist logic to design the technology solution. The literature suggests that neoliberalism is more likely to create or emphasize issues and inequalities that already exist. Technology and software affordances were also analyzed throughout the data sets to assess how the A.I was being framed. The affordances refer to the explicit mentions of how the technology can be used, and how it is framed to benefit stakeholders.

Limitations of the method

Qualitative content analysis is not without its limitations. It is important to identify the possible shortcomings of this method of analysis in order to ensure the research is as reliable as possible. One of the main challenges of this method was the researcher bias, as this research was done by one individual, its important to account for the bias that the researcher already particularly has when it comes to coding. (Noble & Smith, 2015). Also, the quality of the research depended solely on the skills of one individual researcher and that further perpetuates the limitation of personal biases and idiosyncrasies (Anderson, 2010). Another limitation to this method is the time consuming nature of qualitative content analysis. This is due to the volume of the texts that were analysed, and the nature of research focusing on being in depth. Furthermore, since qualitative methods in general are difficult to verify as they are open to interpretation, unlike quantitative methods which are grounded in facts and numbers. This may cause a lack of reliability on the results as they cannot be

verified, which also makes this method an issue within the scientific community, according to Anderson (2010).

4. Results

In order to explore how A.I is being used to tackle water resource management, a total of 40 webpages were analysed. The information was extracted from the websites of three organizations which were the case studies for this research: Banyan Water (20), Staal Instruments (8) and HydroNET (12). Throughout the research, the following themes were found, they are 1) Usage of A.I, 2) Financial considerations, 3) Environmental concerns, 4) Stakeholder interests. For references to the quotes and excerpts from the data sets, please visit Appendix 2.

4.1: Usage of A. I

The theme "usage of A.I" was created in reference to how the organization framed how the end-user may benefit from this technology. This was done by framing the A.I technology as the means to improve their client's existing water management system, which was described in a sub-category as "framing as modern and advanced solution." It is important to note that the aforementioned organizations are aware that water issues are one of the main problems for people worldwide. This informs their framing of the A.I technology, for example, Banyan Water described how "advanced technology to increase visibility and control about the way that it [the water management system] is managed". The organization is framing the technology in a way that centers it as the modern means to have a better sense of water management. Furthermore, Banyan suggest that the A.I technology offered will provide "constant monitoring" which leads to "water being under control", this way A.I is positioned as a means that provides easy, holistic control over water which stakeholders can then manage easily. This framing by Banyan Water about A.I shows that they believe that their technology is going to provide the client with better means to manage water, and the organization does this by framing is as a modern and advanced tool.

The organizations largely acknowledge the existing technology being used to tackle water issues while simultaneously addressing their failures. For example, this excerpt from Banyan Water "after making a series of common-sense decisions around water usage...the school had cut its usage significantly, but not enough to meet its goals" demonstrates that the organization sees that current efforts to tackle water challenges are not good enough see. The organization then goes on to discuss how the "internet of things and data analytics technology could provide a total water management solution". This framing leads to the reader believing that A.I technology allows for a more successful method of water

management. The common sense strategies that Banyan Water was referring to were "watering at night, qualitatively reducing water use and installing natural turf". The limitation of this was that the client could not meet their goals despite reducing water usage. The usage of "total water management solution" thus indicates that compared to these alternative methods, it is the technology and A.I that yields full results.

Another example of how A.I is being framed as the solution to water problems is also an excerpt from Banyan Water which states "your...facility might be unable or unwilling to have outside vendors...Banyan's Total Water Management solutions allow you to still retain maximum water efficiency without risking exposure." This was referring to a context where the client, in this case a school or multifamily complex, would not be willing to have outside visitors due to the current pandemic. Here, Banyan Water wants to assure its clients that the technology is capable of providing a solution at a time where nothing else is possible due to a crisis. This way, the organization signals that its clients can look to A.I as a way to tackle water management in times of crisis. A.I is framed as an advanced, modern solution that works efficiently even when traditional methods don't. Furthermore, this is also evident in another excerpt by Banyan Water whereby the organization stated that, particularly in the winter times, landscapers, inspectors and property owners inevitably fail to maintain watering schedules. The "modern technologies" are a better means to locate water leaks as opposed to landscapers and inspectors.

The second category revolved around the affordances of the technology. The theory of affordances refers to what the technology offers and the features of technology that can be appropriated to meet certain human needs. Affordances of the technology are used to examine the relationship between what the technology can do and how it is being utilized to reach goals. As the context of this thesis is exploring the use of A.I for social good, the relationship that was analyzed is the relationship of the affordances of technology coupled with the framing and how this provided insight on if this is leading towards social good. This category of A.I's affordance being used for water resource management is perpetuated by Banyan Water, when discussing what their solution can offer "implement a tracking procedure so you can manage water without the effort." In this content the affordance of the technology is that it provides the user with comfort and ease for the client. This, however, does not relate to tackling water issues, but instead it is providing incentive for the client to use this tool for their own comfort. This demonstrates profit-oriented goals and framing. In one of their publications where they discussed the benefits of their radar technology, Staal Instruments mentioned that "combining radar and IoT, Staal has developed a small, stand-

alone box that can measure levels of liquids and solids. "This was in reference reference to the preexisting solutions on the market that, according to Staal Instruments, "require a lot of power, are inaccurate in harsh environments, and break down after a few months." Again, nowhere in this framing is there an allusion towards working for social good or decreasing water problems. Instead, Staal Instruments merely boasts about their products affordances compared to their competitions, also presenting profit oriented attitude towards the product as opposed to wanting to help solve a crisis.

4.2: Resource savings

One major theme that was noticeable throughout the analysis was the overarching theme of resource savings. In almost all of the 40 texts that were analyzed, there was some mention of how the client can use this technology to save money or save water. What this refers to is how the case studies framed A.I as a means to save money or even generate money by saving water. This is a huge indication of where the priorities of the organizations lie. It ties into the neoliberal values that the organizations seem to abide by, as generating profit and communicating in terms that place profit making or saving is more important is not in sync with battling the water crisis and diverting the usage for the development of A.I towards a common good. Instead, this theme exemplifies how A.I is being used, and for what reasons, it gives a clear indication of why organizations will opt to use A.I in their initiatives in the future as well, in order to create profit for themselves and their main clients. This theme, in particular, was one of the most prevalent among the texts. All three organizations framed A.I usage as a means to cut costs, save money, reduce overall expenditure on water and so on. This is significant as it demonstrates the neoliberal logic that governs the design of such innovations and provides an insight on the implications of such logic on achieving common good. For example, Banyan Water's article regarding water leaks discusses how facility and property managers can benefit from the A.I technology as it helps them detect leaks and save costs. In their news post, Banyan Water described water leaks as "adding a significant detriment: unforeseen costs", and offered "consistent predictable water bills." Ironically, here, Banyan Water refers to water as a mere burden that is going to cost the stakeholder heavily, instead of treating it like a resource that needs to be cherished. This again ties into the neoliberal values that take precedent, thus overshadowing the will to work towards a common good. In reference to their radar technology, Staal Instruments stated that this technology would only "cost 10% of current systems", they also stated that their radar is "cheaper" than existing methods. Furthermore, Staal Instruments have referred to their radar technology as "budget-friendly", "cost-

efficient", and offers "minimum installation and maintenance costs." This exemplifies the heavy focus on promoting the cost effectiveness of the product. Both organizations promote their product as a cost efficient solution that the client can benefit from. Thus, they prefer to capitalize off of the problems that exist, rather than promote the aspects of the A.I technology that can help with water resource management.

HydroNET has also referred to their A.I technology as "cost-effective" and as "a low-cost compliance monitoring solution." This theme also extended to saving water, as it is the goal for water resource management. HydroNET discussed their efforts in combating the water issues in South Africa, and stated that by using A.I, managers were able to "significantly reduce". Banyan Water directly refers to their technology as a means to "deliver water savings", and mentioned how they "saved 3 billion gallons of water", the organization also stated that "energy and water, reduce costs." Using this language emphasizes the technology's role in reducing water usage. Water savings in the context of these organizations revolves around saving money and resources rather than harnessing excess water and redistributing it. For example, currently due to the coronavirus pandemic, there are many people who are in need of clean, good water resources as it as one of the main ways to stay safe. Unfortunately, according to the UNICEF, 40% of people around the world currently do not have that access (UNICEF, 2020). In the United States, two million people lack access to clean and safe water. However, in the same country, The New York Times reported that the richest people are escaping to luxurious getaways and building $75,000 pools (Bellafante, 2020). This level of disparity and inequality exposes a vital flaw in the approaches of such companies. "Saving water" translates as saving money, and for organizations like Banyan Water, Staal Instruments and HydroNET, it means earning money through selling the product. That is why social good is not actually being achieved through consumption of such solutions.

4.3: Environmental concerns

It is without a doubt that water resource management ties into environmental concerns, so it was not surprising that this theme would come up among the texts. The two main categories that made up this theme were "references to climate change" and "references to sustainability" In terms of climate change, Banyan Water stated in their news post about the dangers of "flooding and droughts", and how global challenges in water are an effect of climate change." The organization added that "significant pressure on a region dominated by the agricultural industry" as a result of climate change as well. Furthermore,

there was mention of "global warming temperatures" and how this will "increase flood risks." These concerns were in reference to water management, as climate change poses a great threat and challenge to this initiative. The organization also spoke about climate change as being a "risk" and "challenges." Staal Instruments further included that "water resilience mounts with population growth and climate change." In terms of sustainability, terms such as "conserve energy", "sustainability priorities" were often used throughout the texts. The case studies have mentioned how their technology allows their clients to "meet sustainability goals", as well as stressing the importance of sustainability to their client's work. Furthermore, the case studies have aligned themselves with sustainable initiatives. For example, this was done by stating that by using Banyan Water's technology, clients would qualify for "green financing." Green financing refers to the reallocation of funds towards organizations, private or public, that want to engage in 'sustainable' actions. Green financing is promoted by the UN Environment Program as a method to incentivize organizations to move towards 'greener' practices. However, the premise of green financing is based solely on providing funds towards organizations. While it is not surprising that within the economic system in which we live and operate, countries and organizations will want to capitalize off of sustainability – but that hinders progress towards common good. This is because whenever such an initiative exists, it automatically becomes less accessible to those who have less financial resources. Moreover, in the context of Banyan Water and using A.I to enhance water resource management, here the organization appears to be more interested in selling their product to companies and marketing it as a way to obtain a green financing ability. Therefore, capitalist values are placed higher than the will and need to work toward water resource management, and it ties into the neoliberal views on innovation and technology. Furthermore, as seen in the appendix there are references to the text towards the assumption that if the A.I technology is being used then the beneficiaries can "meet their sustainability goals" through property analytics that save time and money. Once again, the organization uses sustainability, which is not very well defined in the text, to promote neoliberal notions of profitability.

4.4: Stakeholder interests

The fourth section of the results discusses the impact that stakeholders have within these companies when it comes to that was heavily prevalent in the data collection was the theme of 'stakeholder interests'. This means that in the texts, the case studies have always outlined a specific stakeholder that they are targeting. Banyan Water made this distinction very clear. In many of their texts, they single out "multifamily property managers",

"managing a high rise or office building", "managers of campuses." This gave a clear indication of who this organization is targeting. The organization also often mentions how its technology "increases asset value" for the stakeholders. This indicates that Banyan Water is only targeting those who can afford such luxuries like living in high rise buildings or owning multifamily properties. This class of people are one segment of stakeholders that heavily benefits from integrating this technology into their business ventures. Targeting property managers is beneficial for Banyan Water as an organization because affluent clientele provides material value for the company. Therefore, the neoliberal logic is what governs this interaction between the stakeholder and Banyan Water. However, considering the inequalities in land and property ownership. This organization's texts were clearly targeting bigger organizations and landowners. However, not all of the case studies and articles targeted those exact stakeholders. HydroNET, in particular, seemed to aim their technology at the greater good. For example, the organisation stated that their A.I was used to "benefit water control rooms in South Africa", and it was the only organisation that aimed at an entire nation, rather than businesses. HydroNET also discussed how the organisation was able to provide water management technology for "all water management areas in the country". The organisation also highlighted how their organisation works with "South African water managers", this also gave an indication at who stakeholders are for this technology. Stakeholder theory implies that everyone who the company is affected by is a stakeholder by default. According to Edward Freeman, modern organisations have the following structure: the corporation or organization sits in the middle, meanwhile, it is surrounded by management, the local community, customers, employees, suppliers, and owners (2001). If this were to be applied to the case studies, then Banyan Water would have its main stakeholders as its customers and suppliers and local community. Staal Instruments would have explicitly called customers, local community and management. Lastly, HydroNET would be tied to the local community, customers and suppliers.

Conclusion and Discussion

In conclusion, the analysis of the three case studies provided a basic for understanding how A.I was integrated in water resource management. The technology has shown to be very helpful for companies, especially when it comes to cost-saving and enhancing efficiency using modern technologies. Through conducting a thorough content analysis of the texts presented on the websites, there were four themes that answered the research question. The first theme revolved around the usage of the A.I technology and how that was framed in the texts. This was split into two main categories, "references to technology as modern" and "references to technological affordances." This was significant because it demonstrated how A.I was being framed for the potential users as the solution to use for the way forward. As companies are constantly looking for ways to improve and adhere to the changes in the world, using A.I to enhance water management then appears to be a successful business move. The second theme that arose was financial considerations, and this was separated into two subcategories of "references to cost-savings" and "references to water expenses". The case studies wanted to showcase to their stakeholders and target audience the benefits of using A.I technology to perform water management through referring to the amount of cost savings that will be possible by utilizing their technology. This way, the target audience will be more compelled to partake in using this technology, as it means more costs will be saved as opposed to spent. Furthermore, the expenses of water, such as leaks and irrigation costs were often mentioned and this appeared to highlight the problem for the target audience. The third theme that was identified was environmental concerns, and this was split into two categories of "references to water issues" and "referencing to sustainability". As mentioned in the introduction of this research thesis, water problems are a giant threat to life as we know it. Companies such as Banyan, Staal Instruments and HydroNET know this fact, and they also know how to utilize those issues to market their products and gain profit. Water issues were often highlighted, such as droughts, floodings, and water scarcity as well as rising water levels. This serves to show the audience that these problems need urgent attention, and by using software, corporates, individuals and stakeholders will be able to tackle them. The references to sustainability are evident throughout the texts. The case studies have claimed that by using their technologies, the audience will have a more sustainable approach, which is better for the environment. The concept of sustainability has thus been integrated into the marketing and public relations sphere of the companies, and has allowed them to build a competitive advantage in the market by doing so. The three aforementioned themes give an insight on how the

stakeholders benefit from this technology. The stakeholder analysis demonstrated that based on the metrics of "high vs low influence" and "high vs low importance", government agencies, corporates and landowners have both high influence and importance when it comes to water resource management. Citizens can be seen as mere beneficiaries of the technology but are not directly consulted for decisions with A.I, and thus they have low influence, and low importance. This has direct implications for real life struggles that low income people and the disadvantaged/displaced will suffer from. For example, Flint Michigan is an unfortunate example of what happens when cities are abandoned and neglected. This leads to what is called environmental injustice – where the 'citizens' with the least power are unable to change their course of action because there are always stakeholders that possess more power than them and thus they do not have the ability to be equal (Butler, Scammell & Benson, 2016).

Some stakeholders are seen as more valuable than others. In the case of Banyan Water, the organization makes it clear who their target audiences are: affluent home-owners and business managers. This isolates a large portion of the population, especially as we live in a world with major inequality when it comes to lifestyles and wealth. For example, according the Pew Research, in the United States the highest earning 20% of the country has generated more wealth than half of all U.S income in 2018 Furthermore, same report stated that the wealth inequality is rising, and has more than doubled between 1989 and 2016 (Schaeffer, 2020). This huge problem indicates that there will be a large portion of people who are excluded from accessing the A.I technology, which contradicts the notion of having A.I for sustainability and sustainable development. As mentioned in previous sections, sustainability discourse has become something that marketers use to draw more customers in and increase loyalty (Curtis & Reddy, 2017). If we were to take Fuller's four dimensions of sustainability and apply them to three organization's initiatives, then it would look like this. The first dimension of futurity would be difficult to place for Banyan Water, because the organization places large value on generating and saving costs from its wealthy clientele, and thus there is no indication of technology helping future generations. As for HydroNET and Staal Instruments, the A.I technology that is offered is often geared towards projects that are supposed to help entire communities, and due to the fact that they aim their product at municipalities and governments, they can contribute to a good future for generations.

What is evident from this thesis research is the fact that despite all the innovations that the three organizations have offered, the neoliberal approach towards creating the A.I and promoting it has many disadvantages. This was evident in all the themes, more often

than not the organizations would discuss the affordances of their products and promote them as opposed to their competitors. The framing appeared to be very profit oriented with the organizations alluding to how their solutions provide comfort to the stakeholder rather than framing the solution as better for the consumer than the competitors.

Thus, it is clear that Banyan Water's solution is the least sustainable when pinned against this particular framework as it specifically points out stakeholders that are already part of the wealthy upper class (land owners and property managers). However, there are other problems that arise even when considering that Staal Instruments and HydroNET promote their products to governments. The analysis from the data largely suggested that the organizations operate under a neoliberal logic that prioritizes generating capital and income over achieving common good and sustainable development for the future. This is important to consider in the context of how unequal the world is currently. For example, infrastructure inequality could play a huge role in the lack of accessibility poor people have to the areas with 'advanced' water systems. In the case of Banyan Water, the organization chooses to allocate its resources towards affluent areas and clients, and this, according to Bajar & Rajeev could lead to adverse effects on achieving equality because infrastructure is being built in areas where the stakeholders are privileged (2016). Instead, what organizations should do is focus on allocating the resources and infrastructures towards areas that need it, thereby decreasing the inequalities faced within communities. This would include a transition to a different system where capitalistic notions are not prioritized over the needs of the majority of stakeholders. The research demonstrated that it is important to move past the profit-only, neoliberal logic when designing technology that is made for global good. The resources are present, however what is missing is a system that enables people around the world to gain access to the resources. Therefore, it can be concluded that capitalist values are not compatible with attempting to achieve common good, because it always entails that profit is the priority. To move towards a society that is truly committed to building common good would mean that we have to abandon and unlearn notions of neoliberalism and individualism and instead aspire toward frameworks on real sustainability, and equality.

Limitations

This thesis has potential limitations that may have affected the results and conclusion. First, the requirements for the data collection stated that the body of text that would be analysed must be minimum 300 words. This requirement limited the amount of texts that were analyzed because there was some information that could not be coded, due to

being under the word limit. The information that was on the web pages could have added more insight to the overall data collection and could have fortified the themes that were created. Furthermore, Staal Instruments in particular was a difficult case to analyse, as stated beforehand, only 8 texts from the organization were analysed because only those fit the criteria. Therefore, it could be stated that the restrictions have decreased the ability to obtain a larger data set. Relatedly, Banyan Water was the case study that was analysed the most thoroughly, with 20 texts analyzed, due to the fact that the organization had published text that was longer than 300 words. This may have skewed the results and it made it more difficult to make a generalized assumption about A.I and water resource management because there was no equal split of data sets, as well as a small data set to begin with. Another limitation that arose from this research was the nature of the analysis. Qualitative content analysis is a great tool to perform exploratory studies with, however, when there is one coder that is performing the analysis, a bias may interfere with the process. This may lead to the researcher specifically looking for information that validates the initial thoughts of the hypothesis, and thus omitting any other data that may be present. This analysis was also conducted manually instead of using qualitative data analysis software. Using software is seen as a powerful method that can extract more than manual analysis. Thus, by opting to do manual analysis it may decrease from the amount of data that was analyzed, and thus decreased the ability to generalize.

Further research

For further research, it can be interesting to study how A.I is implemented from an ethical perspective. Environmental problems are very real and pose a great threat to the way we are living right now. This advancement in technology is helpful, however, it cannot advance fully if people are not able to access it freely. From this research, it was clear that this technology was marketed for corporations and landowners. This was especially evident from the Banyan Water case study, where they explicitly mention stakeholders that they are reaching out to. The discussions around A.I being a threat to job security are also relevant for further research, for example, Banyan Water mentioned how organizations and landowners don't necessarily need to rely on individuals to carry out their maintenance, as this can be done through the software they offer. The way that the markets around most of the world operate is by ensuring that stakeholders of capital and ownership can maintain that capital while spending the least money as possible. This makes it more difficult for A.I technologies such as the one's from the case studies - that have potential to do well - to be

accessible for all. Thus, it can be said that the A.I technology *can* be used for good, but further research has to be done on under what system, and under which pretenses can this be achieved. In terms of the research itself, future researchers may opt to perform peer reviews in order to avoid the pitfalls of researcher bias.

Appendix

Appendix 1: Color coding data

Established in 2011, Banyan Water uses the power of data and analytics to deliver water savings to commercial real estate customers. Our sophisticated cloud based software platform has delivered over 3 billion gallons of water savings and associated asset value to our customers. Our savings are real and verified against utility data. We currently have over 733 million gallons of water under management and are growing nationally.

Key:
Usage of A.I
Saving resources
Stakeholder Interests
Environmental concerns

Appendix 2: Code book

Coding Frame: Qualitative content analysis of three organizations that offer A.I solutions to water resource management

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Theme	Categories	Examples from data sets
Usage of AI		IofT and data analytics technology could provide a total water management solution". (Data set #1e, p.2)
		.".Banyan's Total Water Management solutions allow you to still retain maximum water efficiency without risking exposure." (Data set #1h, p.4)
		"...Modern technologies like Banyan's Irrigation Insight solution provide daily main line tests and feedback on actual versus expected flow patterns

	References to modern Solution	to identify irrigation leaks in real time" (Data set #1k, p.5)
		"IT essential in modern water management" (Data set #3f, p.2)
	References to technological affordances	implement a tracking procedure so you can manage water without the effort. (Data set #1p, p.2)
		To reduce the impact of climate change advanced ICT solutions are available worldwide (Data set #3i, p. 3)
		with real-time access to the best available weather and climate information from the Bureau of Meteorology. (Data set #3f, p. 4)
		Based on brand new single-chip radar technology, SenZ2 is able to deliver a breakthrough in remote monitoring of water levels (Data set #2g, p. 4)
		So our users no longer have to visit their sites to track water levels or clean their sensors — saving them a lot of time and money."

Resource savings	References to cost savings	providing our customers with actionable, ==cost saving water management== and data.
		In short, thanks to processes SenZ2 radar ==sensors faster, better and cheaper.==
		implementing IoT technology into Stantec's onsite recycling facility—which enables HP to ==pull significantly cheaper groundwater==
		Not only does it help our planet, but it also makes that monthly utility bill ==a little easier to deal with.==
		==you can begin saving money== when those 100-degree days return.
	References to water expenses	Events are organized just to create ==awareness for water== so that people think ==twice before spilling valuable water.==
		Every month ==we report how much water was used and saved==
		Irrigation Insight® typically ==reduces outdoor water consumption by 50-70%==
		Have you noticed that your ==water costs have risen== over the past few years?

Environmental Concerns	References to sustainability	Part of this effort requires a financial framework that allows developers, owners and operators to ==meet sustainability priorities== (Data set #3f)
		The real estate community and corporate America view ==sustainability as an important social and economic objective with broad implications== (Data set #1q, p.1)
		together with [its] partners, [HP] will lead a ==sustainability revolution fueled by technology."== (Data set #1g, p.4)
		Minimize the impact of increasing water rates and manage your water risk with innovative property analytics that save you time and money while ==simultaneously achieving sustainability goals.== (Data set #1s, p.2)
	References to climate change	==Climate change forces major cities worldwide to deal with flooding== because of more frequent and intense rainfall. (Data set #3f, p.3)
		While threats to ==water resilience mount with population growth and climate change==. (Data set #2)

		The challenges of ==climate change, aging utility infrastructure and growing population require leadership to conserve energy and water,== (Data set #1q, p.3)
		..In addition to ==erratic rainfall patterns warmer temperatures== increase the rate at which water evaporates from sol (Data set #1l, p. 3)
		According to many ==climate experts,== three of the primary impacts we will see as a result of ==global climate change are significant adjustments in rainfall patterns,==

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