ESSAY:

Department of Human Geography

The End of Water Scarcity?

Environmental Determinism and Water Security

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ABSTRACT

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Is there no development without water? Are arid and dry regions destined to face water scarcity? This essay argues that with globalisation and technological advancements in the water sector are making time and place less relevant for hydro securing societies. Instead, relevant for water insecure countries is the asymmetrical access to technologies and management. For instance, landscapes that are preconditioned to be dry are no longer determined to face water scarcity because of desalination industries such as in the case of Saudi Arabia.

This paper will address the three following questions:

a) What factors can explain water scarcity conditions in which they are not geographically pre-conditioned?

b) In what ways have technological interventions created water security for societies living in geographically pre-conditioned physically water-scarce regions?

c) Why is Saudi Arabia, a country who lack access to physical water sources such as rivers, lakes or groundwater not determined to become underdeveloped?

The result from this qualitative research suggests that technological advancements does compress time and space and makes some societies living in dry and arid regions able to access fresh water from far distances. The example taken with the virtual water trading and the polar ice towing illustrates that with the capacity to invest in technologies may overcome environmental deterministic factors.

Keywords: Water Security; Development; Technologies; Environmental determinism

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1. INTRODUCTION

The planet we inhabit is blue and has over seventy per cent of its surface covered in water. The contemporary water architecture on earth consists of 300 transboundary aquifer systems and more than 286 international rivers which together accounts for 40 per cent of all the fresh water for the global population. There is a global network of water flows in which it transforms to different phases depending on where we look, be it frozen as it is in our glaciers and polar ice sheets, liquid as in our lakes or in the shape of vapor that we find in the air we breathe. There is water everywhere, in our bodies, on our food and in all plants and most of the organic materials. How come then that academics, professionals, governments, the United Nations and several think tanks across the globe are warning for a global water crisis?

The global water crisis is existing today, there is no need to forecast this as a crisis of the future. There are, to date, over 780 million people are living without clean water and 2.5 billion people who live without adequate sanitation, 1 million people die every year of water-related diseases and every 90 seconds a child dies of water-related diseases. Water security is a subjective perception. The reason for a subjective approach to water security is because for some societies water comes in too much quantities such as in tsunamis and floods. For others, water is so scarce that the quality is not even on the agenda. In other regions, pollution has become a problem, there is water, but the quality is too toxic to consume and affects both the public health and the environment.

Since the 1990s there has been an increasing amount of research conducted around water scarcity and security. Results have shown that water security may not only be caused by climate and increasing temperatures, but also caused by management and governance issues. This is one of the reasons for why this essay contributes to the knowledge on how water scarcity is caused by water management and not only climate related factors. At the international conference the Stockholm International Water Institute World Water Week in 2018, the argument was often posed by several speakers that "*water is essential for development, no water no development*". This made me wonder, what about the countries that do not have access water because of their geographical conditions, are they determined to become underdeveloped? This thesis is developed to test and see whether there are examples of societies that has overcome the geographical conditions and yet are considered developed countries.

2. BACKGROUND

The existing literature on the water security today belongs in general to the natural sciences and political ecology. Traditionally, water security research has been under the aegis of hydrology and the Integrated Water Resource Management (IWRM) protocol. The gap in the literature is that it does not explain how countries are changing their governance on water management because of their access to technologies. For instance, there is no literature that has studied how societies living in dry conditions are overcoming their water crises because of technocratic

interventions. The reason for why this is an interesting gap to fill is because this initially would mean that geography is not essential for water security.
The concept of water security has continuously been developed since the 1990s (Bakker et al., 2012; Aggestam, 2015; Schmidt et al., 2017). The concept of water security emerged as a discussion of an alternative security. For instance, before the 1990s security was mainly narrowed to the military and defense aspects and after the post-cold era there was more inclusive security threats (Devlaeminck et al., 2018, p. 96).

Water insecurities impacts societies on different levels that is some experience water in overflows while others don't have access to fresh water sources. What is interesting is that water in itself was not defined as a natural resource until the 1909's in the U.S. (Schmidt 2017). Furthermore, the neo-liberal economic policies that evolved and shaped the global trade market in the 1970s and 1980s has also contributed to how we define water security and see water as a resource and even commodity. The increasing interest in water from economists since the 1970s to see water resources as a factor for development has also influenced policymakers and governance scholars to participate more frequently in global water security. For instance, the World Bank in the 1970s and the 1980s frequently financed about eight dam projects per year and since 1986 the bank has approved 39 dam projects, where 33 of them are exclusively for hydropower (The world bank, 2018). Dam constructions, however, does not come without the risk of conflict (Swain, 2018) and the United Nations Security Council on 26th October met in an Arria-formula meeting to explore the ways for the UN system to address water scarcity as a root cause of conflict to prevent conflicts to occur around water (Bapna et al., 2018).

For this reason, due to the conflicting interests and politics that is around water there needs to be more studies on the examples that have overcome water scarce conditions and how they have done it. The pre-conditioned geographical factors such as dry and arid lands are one way of explaining how technologies has been used to overcome these deterministic factors. Now, in the human geography literature we can find answers to the questions of whether societies are determined to be conditioned by their environment (Judkins et al., 2008). One particular concept that has influenced the different ways of approaching this thinking is globalization and technological inventions. For instance, globalisation is acting like an emperor without a kingdom, affecting nation-states, cultures and societies around the world to become more homogenized but also interconnected. For the water sector this has been evident that distances and time has shrunk and made some societies be able to provide their households with water despite their landscape. For instance, it is no longer common to walk long distances to collect water takes that takes time, which could have been put to something else, for instance, in Sweden every household has a tap water system that within a second serves one clean and fresh water.

2.1 Purpose statement

The overarching aim of the research is to study how the theory of environmental determinism can be applied to the study of water security by using the case example of Saudi Arabia. Also,

to study whether geographical conditions that create physical water scarcity, such as dry and arid landscapes determine a society's ability to become water secured.

2.2 Research questions

This paper will address the three following questions:

- What factors can explain water scarcity conditions in which they are not geographically pre-conditioned?
- In what ways have technological interventions created water security for societies living in geographically pre-conditioned physically water-scarce regions?
- Why is Saudi Arabia, a country who lack access to physical water sources such as rivers, lakes or groundwater not determined to become underdeveloped?

2.3 Disposition

The structure of this essay is organised into several sections first Background, Theory, Methodology, Result and Conclusion. In this section, the background for the research questions is explained, then which methodology is used and the necessary framework and theory needed for the thesis. When the methodology is explained then the result section will illustrate the findings, and finally discuss the conclusion of these findings.

THEORY

3.1 Framework

In this section, the concepts used in this thesis will be described. First, the concept of water security will be defined and its development. The reason for this explanation is because the concepts subjective meaning and how it may affect the result. The second concept is environmental determinism which is central to the understanding of the argument in this thesis. The water security concept has since the 1990s the concept been developing continuously (Aggestam, 2015; Bakker et al., 2010). The concept changes according to space and time, meaning that what is water security in Somalia does not necessarily mean water security in South Korea. For this reason, perceptions of what constitutes a water-related risk and security will now be illustrated in the different quotes below.

The World Water Council, which is a French international multi-stakeholder platform that focuses on engaging people in debates on the political dimensions of water security, adaptation and sustainability, defines water security as: *Following the sustainability paradigm that proposes equal prioritization of social, economic and environmental issues, water security has the same three dimensions: social equity, economic efficiency and environmental sustainability […] The reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risk* (World water council, 2018, p. 169). The definition has a political dimension to water security, which is also called hydropolitics. In this statement we see that an acceptable level of water-related risks

constitutes water security, in other words, the more reliable a water source is the higher level of Hydrosecurity. For the former Harvard professor in Environmental Engineering also director of the Harvard Water Security initiative John Briscoe water security is defined as:

> Water security is rooted in water's contribution to the "good life" Thus "An adequate supply of water of reasonable reliability and quality—for people, industry, agriculture and energy—is essential for the well-being of societies. Second is the "Goldilocks" concept: that is, societies need just the right amount of water—not too little (few periods of scarcity) or too much (few periods of inundation). Third is the concept that building the institutions and infrastructure to provide water security involves financial and environmental tradeoffs. Fourth and finally is the idea that context matters: people and governments choose to situate themselves at different points on the "risk/cost curve" depending on levels of development and social values. (Briscoe, 2015, p. 28).

In comparison with the former quote from the World Water Council, Briscoes definition is more into explaining the dimensions of the significance of financial institutions and the infrastructure. In this definition water security becomes more as in living standards, what Briscoe calls the *good life*. Then, water security according to the Professor Malin Falkenmark, who is also serving as a senior scientific advisor to the Stockholm International Water Institute and was the former Executive Secretary of the National Committee for UNESCO's International Hydrological Decade Program housed by the Natural Science Research Council of Sweden, the concept is defined as:

> Water security may be seen as a tolerable water-related risk to society. Water's social and productive potential meets human society in two main ways: on the one hand, as liquid (blue) water to meet hygienic, health and economic requirements (including irrigation) and, on the other hand, as the infiltrated rainwater in the soil (green water) that operates the production of food and other biomass. To be water secure, an individual needs about 1200 m^3/p yr, but a strong economy can afford to import water-intensive commodities. A central question for humanity's future is therefore whether there is enough water in the global system to meet the demands of tomorrow's world population. Unless action is taken now, water insecurity is likely to become a critical geopolitical issue that affects the entire global economic system. This involves both harnessing water's social and production potential and limiting its destructive effects (Falkenmark, 2013, p,1-2)

Falkenmarks definition in comparison with the former quotes is also related to the tolerable water-related risks but points also out the world population and its demands. That is, that the demand of the increasing water is posing a water security threat. Another significant detail is the role of geopolitics in Falkenmarks definition, that indicates that water security is not only a matter of hygiene it is also a factor that can trigger international disputes and conflict. This in turn could lead to what geopolitical scholars call "Water wars".

The Canada Research Chair and Professor in Water Governance Karen Bakker and her Human Geography PhD student and college Cynthia Morinville water security is defined as a*n acceptable level of water-related risks to humans and ecosystems, coupled with the availability*

of water of sufficient quantity and quality to support livelihoods, national security, human health and ecosystem services (Bakker et al., 2012, p. 1). Bakker's and Morinville's definition correlates much with the previous definitions, but also mentions the importance of the health of the ecosystem services.

Then, Dr. Jeremy Schmidt who is a lecturer in Human Geography and author on several books on Water Ethics defines the concept as:

> Water Security deals with both conservation and development and that there is no single perspective or silver bullet that is better positioned than another. Water security entails that there is a rational judgment and premise that there is no water matrix that is infinitive, meaning that water will come to an end. What distinguishes water security from another are the programs to deal with the consequences of water scarcity and abundance, not to mention the preventative measures to mitigate potential international conflict, also, to secure human development and a healthy ecology. In conclusion, the concept water security includes all water threats be they scarcity, overflow or pollution (Schmidt, 2010, p. 30).

From this perspective, we see that water security relates to the subjective perception, again, there is no silver bullet that is better positioned than another. As well as Bakker and Morinville, Schmidt mentions the role of a healthy ecology where water plays a significant role. For Schmidt, who is also a researcher in the Anthropocene, water is regarded as a finite resource in which humans need rationally take care of.
Finally, for the United Nations (UN) water security is:

> The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters and for preserving ecosystems in a climate of peace and political stability. (UN Water, 2018).

The UN does mention the protection of water-borne pollution as a risk towards security, and also, as Schmidt mentioning the significance of preservation and conservation. Security means therefore protecting the access to adequate quantities of acceptable quality water for sustaining humans and their development.

In conclusion, as illustrated in this section there is no agreement among scholars or professionals on the meaning of water security. However, several scholars did agree on the acceptable water related risks. For this thesis, all perspectives of water security are included. To clarify, the first definition of the term means that there is enough water quantity for food security and hygiene, then quality so that both human and the health of ecosystems is long-term sustainable. Like air, water is a prerequisite for human existence, therefore, water should be understood as a coequal human right.

The concept of environmental determinism is the understanding of the relationship between nature and humanity. The theory argues that regional variations of human cultures and societies

are determined by the physical and biological forms that make up the piles of earth many natural landscapes (Brooke, 2016). The position is that human condition is determined by nature and the environment that surround the man, but also vice versa. As an example, the Anthropocene theory explains this relationship, for instance how humans are destabilising the earth systems because of their behaviour. Several geographers and biologists such as Humboldt and Darwin have discussed environmental determinism and today it is relevant to the climate change agenda (Brooke, 2016). The theory searches for the relationship between human and their environment. The environment is the elements that compose the physical aspects of nature and their groupings in landscapes and ecosystems. The environment has varying degrees of determinism and determinism states that every event, except the first, is causally needed by antecedent events (Stanford Encyclopedia of Philosophy, 2018). In sum, the concept explains the effect of physical and geographical conditions to human society and that they are conditioned because of their geographical location.

4. METHODOLOGY

This research is a qualitative textual analysis and a participation/observation study from the Stockholm World Water Week (2018). For the textual analysis, I have used several primary and secondary books and documents sources. A textual analysis, according to the scholar Alan McKee is *textual analysis is a methodology for gathering information about sense making practices, that is, how members of various cultures interpret the world around them* (McKee 2003, p. 52). In this research there has been information gathered through documents and literature found at several data bases such as Web of Science; Uppsala University Online Library; Dag Hammarskjöld's Faculty of Law Library, Uppsala; Stockholm University Library; Anna Lindh Library, Stockholm; Google Scholar; University of Toronto library; Toronto Public Library; Thomas Fisher Library, Toronto; University of Geneva library; UN library (UNOG). Finally, publications in *The Water Network* were also consulted. When consulting these databases, the material related to answering the research questions was used, for instance focusing on the case of Saudi Arabia. Mentioning the use of concepts is significant in the qualitative research because concepts, because of their role in the use of methodology (Bryman, 2016, p.382).

The concepts searched were ‘water development’, ‘water security Saudi Arabia’, ‘water security’, ‘water technology’, ‘environmental determinism’, ‘water conflict’, ‘water scarcity’ and ‘water infrastructures’. The timeframe chosen for the results in the databases were 1990-2019. The reason for choosing the starting point at 1990 is because the concept of water security has continuously been developed since this year (Aggestam, 2010). The qualitative textual analysis was based on the findings from these concepts used, however, the framework did narrow the result and there were other criteria used to choose relevant literature. First, there was an attempt to use peer-reviewed article and sources that where academic and not only rapports from NGO’s or other politically biased sources. The water network provided good information that was entirely focused on water related issues, from there I moved to find relevant authors

and other sources during my literature review. The reason for choosing a qualitative research based on literature analysis as methodology is because literature is a broad source range of sources. Also, it increases the reliability and transparency of the research in which the participation at the conference could not contribute with. According to A. Bryman (2016), *qualitative researchers tend to espouse an approach in which theory and empirical investigations are interwoven* (Bryman, 2016, p. 70). Bryman's observations are significant for the methodology used in this research because the theory used that is *environmental determinism* and *water security* are both part of theory and investigation. The theoretical definition of these concepts will be illustrated later in this section.

The literature as sources together with the observations made from the Stockholm International Water Institute World Water Week (SIWI WWW), served as answers to the questions asked in this research.

The conference is annually organized by SIWI and the 2018 conference had over 3,300 individuals and 380 convening organizations from 135 countries. The people attending the conference were water experts, practitioners, decision-makers and business innovators. The conference held several different lectures from all over the world, which contributed to a world-wide perspective. Before attending the conference, several lectures were highlighted in the conference program, so that a broad perspective from water-related risks was gained. The concepts high lightened was the concepts of '*water security*', '*water and development'* and *'water technologies. Then, the attended lectures where from* the African, Asian, European, North American and Latin American regions. This conference has been referred to as 'SIWI WWW' in the essay where the conference itself represents a source of information. The use of this methodology may be regarded as vague or non-transparent, however, it is significant for the main argument in this thesis to explain where the questions emerged from.

In sum, the selected qualitative research methods used in this research has been useful to answer the research questions. However, there is more than one possible explanation for the research questions. However, at least the questions focus on theory and the problematization of applying it to water security which initially means that the research needs several literature sources. Then, when combining what has been observed and the data collected from SIWI WWW 2018 the literary works as an instrument for source criticism, to test whether the arguments are valid or not. However, we cannot forget a researcher's subjective point of view which creates bias in the result also the reliability of the result is therefore questioned (Bryman, 2018, p.392).

4.1 Delimitation

In this research, there has been a choice to only choose one case study as empirical evidence, in this case it is Saudi Arabia. The reason for choosing Saudi Arabia is because of their landscape, mainly being desert, dryland and having no rivers or lakes in their territory, all these factors constitutes to the example of a country that is not geographically advantaged to fresh water security. On the other hand, a major source of uncertainty is in the method used to calculate the current state of development of Saudi Arabia to argue that it lacks water but that it's not underdeveloped because of this variable. However, despite their dry and arid landscapes

they are not an underdeveloped country according to the sources used and they remain the main consumers of water in the world. It is because of these to facts that the case is suffice as empirical evidence for this thesis. The result may be affected by only using one country as an example, however, this is regarded as an experiment that needs to be tested several times on other countries for validation. Due to the time restriction and the size of the thesis, there was a choice to only choose one country as an example.

Another limitation when studying the case of Saudi Arabia, there was no direct contact with local people from the region and for a more reliable result, a field study or at least an interview could have contributed to more data and information about the case. As regarding using SIWI WWW as a complementary source of information, in observational studies, there is a potential for bias from my own perceptions of water security. For this reason, the literature used increased the different perspectives available to answer the research questions.

5. RESULT

5.1 Water and development

Findings in the literature explains that the contemporary water architecture consists of 300 transboundary aquifer systems and more than 286 international rivers which together accounts for 40 per cent of all the fresh water for the global population (Swain, 2018). Water plays an essential role in every single aspect and function of life. Some pre-Socratic philosophers have even argued that water was the first principle as everything. Others today finds water the matrix of life and to think that water is finite within that matrix constitutes our ability to reason (Schmidt, 2017; Franks, 2000). It is human's universal dependency to water for survival that makes us vulnerable to the water scarcity and pollution. Today, there are over 780 million people are living without clean water and 2.5 billion people who live without adequate sanitation, 1 million people die every year of water-related diseases and every 90 seconds a child dies of water-related diseases (Swain, 2018).

Observations made from the attended lectures at SIWI WWW (SIWI WWW, 2018) suggests that the concepts of water and development are increasingly used in research. Since the 1990s the concept of water security has increasingly been used and developed (Bakker et al., 2013; Aggestam, 2015). Water is essential for development, both for human development as biological entities but also for societies to survive. Now, in the 21st century, several think tanks and organisations report that the fresh water is coming to an end and that one-third of the world's population will face water scarcity (UN, 2018; World Economic Forum, 2018). The idea of a limited available freshwater quantity on earth is discussed by the scholar Jeremy Schmidt, and he explains in his book *Water: Abundance, Scarcity, and Security in the Age of Humanity* that it belongs to the rational mind to think of water as within a finite matrix (Schmidt, 2017). It appears as if, however, that the idea of water as a finite natural resource did not begin until the 20th century, in the US for instance, water was not defined as a natural resource until the 1909s (Schmidt, 2017).

Several sources in the literature reviewed and observations from the SIWI WWW suggest that water security is a subjective perception, where for some water is more appearing as an enemy where it comes in too much quantity, while for others, access to water is not possible because of economic, geographical or political factors. As water plays an important role both for food security and public health, it is essential to have a functional water sector in a society to manage and govern the water sources with a sustainable and long-term strategic planning. However, it appears as several scholars have thought of water scarcity as more of a management and governance issue rather than an entirely causality to geographical conditions (Bakker, 2010). For this reason, one of the main arguments posed in this thesis is that water scarcity is not only caused by deterministic environmental factors, instead, but the human behaviour and its capacity to intervene with technological instruments also appears to become more significant for water securing societies.

Therefore, the main argument in this essay is that the causalities explained in the environmental deterministic theory on the lack of water and development appears to become vaguer. The reason for this is because there exist technologies that humans use as instruments to mitigate and overcome the geographical preconditioning landscapes in which societies are developing on and surrounded by. However, mismanagement and lack of governance are one of the reasons for freshwater scarcity. This will argument will be further explained and analysed in the coming chapters. Now, let us examine how management and governance affect water scarcity.

Findings suggest that there are factors such as mismanagement and lack of governance that may contribute to water scarcity, even more than geographical preconditions. These factors could be ageing water infrastructure, leakage and mismanagement (Bakker, 2010). For instance, the American Water Works Association in 2017 reported in the *State of the Water Industry Report* that ageing water and wastewater infrastructure is the primary concern for water utilities in North America causing scarce water conditions. Phenomenon's such as the causalities of climate change is instead, according to a speaker at SIWI WWW during the *African Water Ministers* lecture, a used concept for blaming someone else or something else for water insecurity in the society, instead of taking responsibility for the water insecurity themselves. For this reason, climate change is not the only way to understand water scarcity it can also be caused by mismanagement and lack of governance. For instance, in the US alone, the contemporary water infrastructure architecture consists of nearly 1.9 million kilometres distribution supply for drinking water (Walton, 2016). The water infrastructures leakage problems are of concern and are also a potential threat to public health as the wastewater pipelines also leak (Puust et al., 2010). Another example is the United Kingdom, where the total amount of water lost to water leakage accounts for over 3,100 million litres per day which is equivalent to 1,273 Olympic swimming pools (Discover water, 2018). What is interesting with the findings from the examples of the US and the UK is that much of the water lost could be reasons for why both the US and the UK is facing water scarce conditions despite their geographical preconditions in access to both sea, rain and groundwater.

5.1.1 Globalization, virtual water and the demography of water demands

In today's globalised world, freshwater scarcity is no longer a regional issue only it is an international one. A common argument among water security researchers in the literature reviewed and professionals lecturing at the SIWI WWW (2018) is that: Water is becoming scarce because of an increasing world human population ad this argument stems from the theory of Robert Malthus, who back in the 1900th century observed that the rapid growth in population led to an increasing demand for critical resources, including water (Whitehead, 2014). Now the trends and projections from several think tanks, organisations and institutions are that the available freshwater resources on earth are less in quantity to be able to supply the increasing demand for it. For this reason, as the demand for water continues to increase and water is seen as a finite resource, theories of conflict around water resources have emerged. As fresh water becomes a limited resource interest both from the private and public sector may contribute to conflict (Flint, 2005; Le Billion, 2009), but also cooperation which is usually the norm in water sharing (Shaqul, 2017; Schmidt, 2017; Swain, 2018).

Another interesting finding is the one the scholar Hans Rosling argued that the only way to stop population growth is to raise the standard of the poorest (Gapminder, 2018). On the other hand, an increase of the middle class also increases the demands for water. For instance, in South America and Asia alone, the middle class appears to be rising (Bussolo et al., 2014; Bruckener et al., 2018). This phenomenon seems to create a larger group with purchasing power and most likely increase the demand for products that need water for production. However, reports are suggesting that the middle class in other places such as Europe, for instance, is instead on a decline (ILO, 2018). The middle class as a purchasing power could lead to an increase in food consumption and industrial produce which initially demands more water both in quality and quantity. The correlation of demography, socioeconomics and management in the water sector contributes to the progress of a societies capacity to develop and the correlation appears to not be environmental deterministic because of globalisation, which will be explained with more details now.

Regarding fresh water scarcity, several factors affect its quantity and quality in which is not determined by geographical factors. For instance, as the literature shows, in the case of population growth and also an increase in the purchasing power of the population in the most population dense continents such as Asia and South America, they may see a shift in the consumption in both food and produce. This will need more water to feed all the demands, but geography is no longer a limitation. To illustrate this the concept of *Virtual Water* will now be applied and analysed. As illustrated in Table 1 below, what stands out is the amount of water needed to produce food, in particular meat and coffee. If we first look at the meat production, we see that the

Product	USA	China	India	Russia	Indonesia	Australia	Brazil	Japan	Mexico	Italy	Netherlands	World average
Rice (paddy)	1,275	1,321	2,850	2,401	2,150	1,022	3,082	1,221	2,182	1,679	—	2,300
Rice (brown)	1,656	1,716	3,702	3,118	2,793	1,327	4,003	1,586	2,834	2,180	—	3,000
Rice (white)	1,903	1,972	4,254	3,584	3,209	1,525	4,600	1,822	3,257	2,506	—	3,400
Wheat	849	690	1,654	2,375	—	1,588	1,616	734	1,066	2,421	619	1,300
Maize	489	801	1,937	1,397	1,285	744	1,180	1,493	1,744	530	408	900
Soybeans	1,869	2,617	4,124	3,933	2,030	2,106	1,076	2,326	3,177	1,506	—	1,800
Sugar cane	103	117	159	—	164	141	155	120	171	—	—	175
Seed cotton	2,535	1,419	8,264	—	4,453	1,887	2,777	—	2,127	—	—	3,600
Cotton lint	5,733	3,210	18,694	—	10,072	4,268	6,281	—	4,812	—	—	8,200
Barley	702	848	1,966	2,359	—	1,425	1,373	697	2,120	1,822	718	1,400
Sorghum	782	863	4,053	2,382	—	1,081	1,609	—	1,212	582	—	2,850
Coconuts	—	749	2,255	—	2,071	—	1,590	—	1,954	—	—	2,550
Millet	2,143	1,863	3,269	2,892	—	1,951	—	3,100	4,534	—	—	4,600
Coffee (green)	4,864	6,290	12,180	—	17,665	—	13,972	—	28,119	—	—	17,000
Coffee (roasted)	5,790	7,488	14,500	—	21,030	—	16,633	—	33,475	—	—	21,000
Tea (made)	—	11,110	7,002	3,002	9,474	—	6,592	4,940	—	—	—	9,200
Beef	13,193	12,560	16,482	21,028	14,818	17,112	16,961	11,019	37,762	21,167	11,681	15,500
Pork	3,946	2,211	4,397	6,947	3,938	5,909	4,818	4,962	6,559	6,377	3,790	4,850
Goat meat	3,082	3,994	5,187	5,290	4,543	3,839	4,175	2,560	10,252	4,180	2,791	4,000
Sheep meat	5,977	5,202	6,692	7,621	5,956	6,947	6,267	3,571	16,878	7,572	5,298	6,100
Chicken meat	2,389	3,652	7,736	5,763	5,549	2,914	3,913	2,977	5,013	2,198	2,222	3,900
Eggs	1,510	3,550	7,531	4,919	5,400	1,844	3,337	1,884	4,277	1,389	1,404	3,300
Milk	695	1,000	1,369	1,345	1,143	915	1,001	812	2,382	861	641	1,000
Milk powder	3,234	4,648	6,368	6,253	5,317	4,255	4,654	3,774	11,077	4,005	2,982	4,600
Cheese	3,457	4,963	6,793	6,671	5,675	4,544	4,969	4,032	11,805	4,278	3,190	4,900
Leather (bovine)	14,190	13,513	17,710	22,575	15,929	18,384	18,222	11,864	40,482	22,724	12,572	16,600

Table 1: Average virtual-water content (m3/ton) of various products for selected countries. (Source: Hoeckstra et al., 2008, p. 14)

water needed to produce Beef, Pork, Goat, Sheep and Chicken need much water. The beef production, in Table 1, is the food product that holds most virtual water. Another interesting detail in Table 1 is that if we look at Beef production, we see that every country produces Beef and they probably consume this locally as well. Now, if we look at coffee, both Green and Roasted, on the other hand, not all the countries produce coffee but most likely consume coffee.

Also, what is significant but not illustrated in table 1 but rather in table 2 is that the coffee production is not necessarily consumed in the geographical place where the water is extracted for coffee production; instead, the coffee (virtual water) is exported to places that have cero coffee production in table 1. For instance, as the scholars A.K. Chapagain, A.Y. Hoekstra argues in their article *The water footprint of coffee and tea consumption in the Netherlands* that:

> In total, the world population requires about 140 billion cubic metres of water per year in order to be able to drink coffee and tea. The standard cup of coffee and tea in the Netherlands costs about 140 l and 34 l of water respectively. The largest portions of these volumes are attributable to growing the plants. The Dutch people account for 2.4% of the world coffee consumption. The total water footprint of Dutch coffee and tea consumption amounts to 2.7 billion cubic metres of water per year (37% of the annual Meuse runoff). The water needed to drink coffee or tea in the Netherlands is not Dutch water. The most important sources for the Dutch coffee are Brazil and Colombia and for the Dutch tea Indonesia, China and Sri Lanka (Chapagain et al., 2006, p. 1).

As Chapgain and Hoekstra argued this is an example of how the virtual water concept operationalises on earth. Virtual water trading works are also explained in this table and Table 2, where the world coffee consumption is illustrated. Looking at Table 1, we see that the leading

World coffee consumption
In thousand 60kg bags

	2013/14	2014/15	2015/16	2016/17	CAGR (2013/14 - 2016/17)
Importing countries (Coffee years: October - September)	***102 964***	***104 714***	***107 930***	***106 892***	***1.3%***
European Union	41 534	42 524	43 076	42 567	0.8%
USA	23 901	23 743	25 336	25 775	2.5%
Japan	7 501	7 594	7 790	7 913	1.8%
Russian Federation	3 948	3 846	4 303	4 638	5.5%
Canada	3 805	3 620	3 598	3 783	-0.2%
South Korea	1 873	1 963	2 161	2 316	7.3%
Algeria	2 147	2 158	2 282	2 223	1.2%
Australia	1 543	1 713	1 720	1 847	6.2%
Saudi Arabia	1 321	1 566	1 405	1 430	2.7%
Turkey	892	1 078	1 106	1 378	15.6%
Ukraine	1 246	1 106	1 124	1 120	-3.5%
Switzerland	1 010	1 052	1 069	1 088	2.5%
Norway	764	765	774	798	1.5%
Taiwan	505	556	591	713	12.2%
Egypt	529	564	680	177	-30.6%
Israel	583	603	597	678	5.2%
Sudan	716	618	629	160	-39.3%
Argentina	619	610	546	596	-1.2%
Morocco	568	573	584	596	1.6%
South Africa	505	571	556	589	5.3%
Others	7 455	7 891	8 001	6 506	-4.4%

© International Coffee Organization

Table 2. Shows the worlds coffee consumption in thousand 60kg bags. (Source: ICO)

coffee producers that use a high quantity of water are India, Indonesia, Brazil and Mexico. In Table 2 here below, the world coffee consumers in the world are illustrated to show where in the end the coffee is consumed, in other words, where the end user for the virtual water is located.

From Table 1 we saw who the main producers wherein Table 2 we see the primary consumers. This is relevant to understand the virtual water trading, where water is extracted in one place to produce a commodity that is later traded and consumed elsewhere. For this reason, water may become a regional scarcity but only for the once producing certain products that need a high quantity of that is explained in the virtual water concept. What is interesting in Table 2 is that main consumer such as the USA (who is only producing a low amount of coffee), Russian Federation, Canada, Saudi Arabia and many European countries consume the highest amount of coffee although they do not produce it. This was an illustration of how virtual water trading takes place, now let us further examine how this works as a factor that creates water scarcity, but which is not determined by geographical pre-conditions. Instead, water scarcity becomes a regional problem for those living in the areas where coffee is produced, but not necessarily for

the end user of coffee because they may have access to water sources even if water scarcity becomes a problem in one of the leading coffee producing countries. As an example, Norway according to Table 2. Consumes coffee and has regional water sources, while Mexico, on the other hand, may use their water to produce coffee because it is one of their main exports, then end up without physical water because of the virtual water trading. In this case, Norway may stand without coffee but still have sufficient water, while Mexico, on the other hand, has lost both a source of income and also access to physical water.

From the perspective of the other way around, virtual water trading can still also work for the countries that lack access to physical water which is evidence for the argument that societies are not determined to end up water scarce despite their geographical location. In sum, the illustrated examples of virtual water earlier work as counterarguments for the deterministic environmental argument based on the notion that countries will become underdeveloped if they have no access to water. Because water is still traded with and water scarcity is an international governance and management issue not entirely determined on the regional environment.

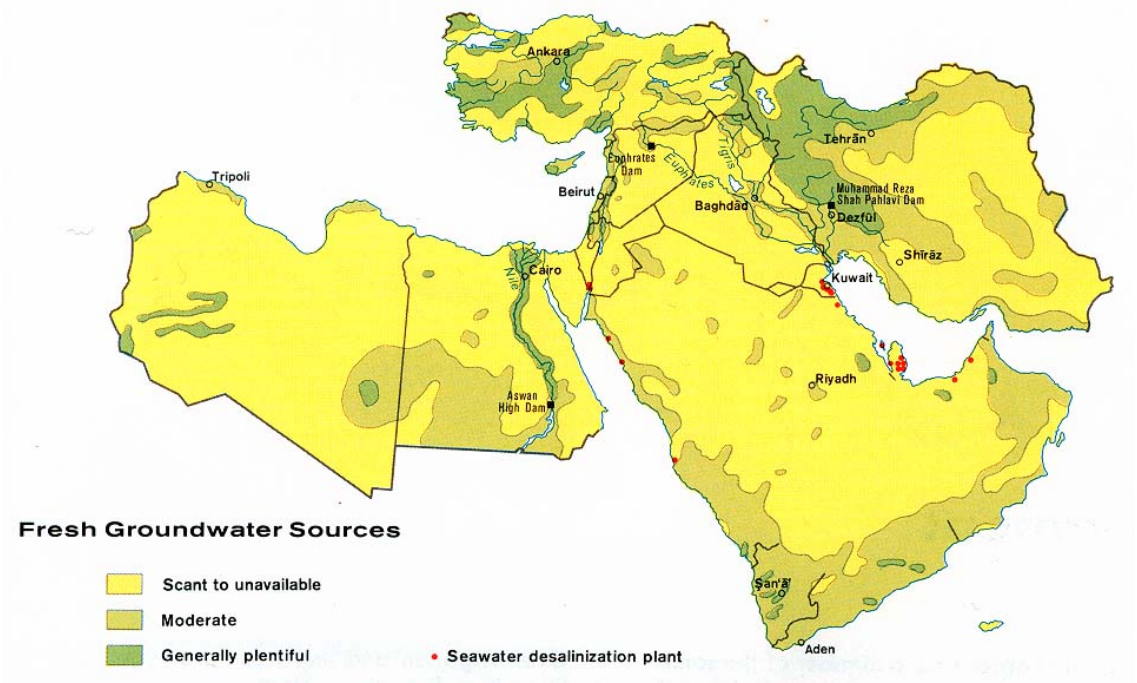
5.2 Environmental determinism and water security

Environmental conditions are not the only causality for freshwater scarcity in societies. For societies living in dry and arid landscapes with high temperatures and low humidity, several other deterministic factors are significant outside of the theory that societies are shaped entirely by their environment. This section will now illustrate how societies are becoming less and less dependent on environmental conditions and more depending on technological interventions for their domestic water security.

First, it is the access to technologies that contribute to water security in countries which lives under geographically water scarce conditions, such as those in dry and arid terrains and landscapes. This argument is illustrated by using the case examples of Saudi Arabia. Second, because of globalisation water becomes both virtual and objectified substance that is traded across the world, making societies able to hydro-securitise themselves to water access if they can economically invest in water. These two arguments are examples of how environmental determinism is becoming a vaguer explanation for why societies are living under water scarcity and are underdeveloped. Now, the ways that technological interventions have created water security for societies living on dry and arid terrains will be illustrated, also investigate whether these societies are destined to become underdeveloped because of their lack of access to freshwater sources.

5.2.1 The Geography of Saudi Arabia

The Saudi Arabian capital Riyadh is located in the dry and arid landscape of Najd close to the inner core of the country, see Map 1. Most of the Saudi Arabian terrain is sand deserts and steppe landscape. Rainfall is minimal in the southern parts where it has no more than 100mm per year, while in the northern regions it can rain up to 100-200mm. Water is physically scarce in this part of the world and with elevated temperatures up to 50°c where the water quickly evaporates from the ground, and surface leaves the region determined to face water scarce conditions without technological interventions. The country has a coast to the red sea in the west and to the Persian Gulf in the east, which has led the country to be able to develop seawater desalination plants in the region, as illustrated in the Map 1 with the red dots.



Map 1. The fresh groundwater sources in the Middle East, with Saudi Arabia illustrated, see "Riyadh" for location. (Source: University of Texas)

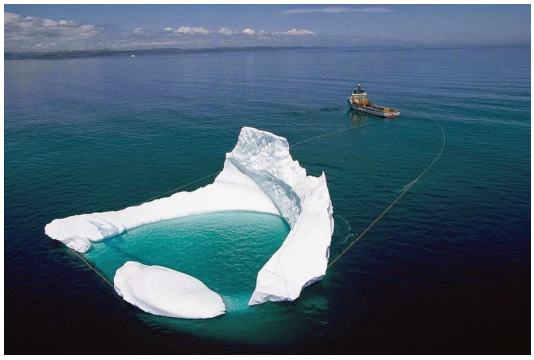
5.2.2 Access to technologies

A straightforward example of how technologies are contributing to water security is the domestic access to water supply pipelines to their tap water systems in households and this is a contrast between urban and rural regions. Findings in the literature shows that, in 2014 around 83 per cent of the Saudi Arabian population resides in urban areas (Lovelle, 2015). The urban demands pressure the rural regions to supply the demands from the city, including the water supply. There is a significantly higher demand in the urban areas with an estimated 100-350 litres per day demand in comparison with the 15-20 for the rural areas in the region (Lovelle, 2015). The access to tap water systems has made the water use easier for every household, however, in the province and rural area of Najran which is located in the border to Yemen the

number of households accessing and depending on the municipal water sector is low. In a research conducted by M. Sadiq and G. Hussain, they found that of the 1500 people interviewed only 10percent of them depended on municipal water (Sadiq et al., 1990). While, on the other hand, the urban area of Riyadh depends almost entirely on municipal water supply (Ouda, 2013).

Another interesting finding in the literature is that the time spent on collecting water is essential when we want to study how technologies are contributing to the *space-time compression* (Harvey, 1989). For instance, the time spent on collecting water for those who lack municipal water supply systems in the rural areas is far more than those who have access to the domestic tap water systems in urban areas. Households that access tap water systems are less impacted by geographical distances, the reason is that of the water sectors supply architecture. Now there will be several technologies used as examples to illustrate how Saudi Arabia as a country mostly (approx. 40 per cent) covered by desert terrain is able to be one of the main water consumers in the world. Also, how technological interventions such as iceberg towing could mean water security for people living in desert terrains.

Saudi Arabia is one of the primary water consumers in the world, even though they live in geographically preconditioned water scarce landscapes, as illustrated in Map 1. Despite living under water scarce conditions, the average consumption per person is 350 litres per day in comparison with the European equivalent of 130 litres per day (The water network, 2018). The reason for why access to the sea is significant is because of the possibility of establishing desalination plants, Saudi Arabia is the world's biggest users of desalination technology (The water network, 2018). From the perspective of applying the deterministic environmental theory, the survival and development of a society such as Saudi Arabia may not have been able to progress without access to the sea. On the other hand, it is due to the technological interventions that access to fresh water (de-salinised water) has been secured for the Saudis (Water technology, 2018). Also, a significant fact is that to fuel the thirty desalination plants Saudi Arabia oil is needed as it uses up to 1.5 million barrels of oil per day, which is more than the entire oil consumption of the United Kingdom (The water network, 2018).



Picture 1. A boat towing away an iceberg. (Source: Amusingplanet.com)

A discourse that was held at the SIWI WWW was also around water trading, this has also been found in the literature and in particular the idea of towing polar ice has been a plan for the administration of the Kingdom of Saudi Arabia since the 1970s. As explained earlier, there are indicators such as the virtual water concept that suggests that in a globalised world the water consumed will be somewhere else instead of where the water was extracted. Also, technological interventions allowing polar ice to be towed from Antarctica mitigates the relevance of geographically water scarce conditions for societies. In the 1970s the Saudi Prince Mohamed Al-Faisal held two conferences on planning to tow

icebergs from the Antarctic to Saudi Arabia (Smedley, 2018). Now, these plans do suggest that geographical distances do matter — for instance, the distance towing the iceberg back from the Antarctic to Saudi Arabia does matter because of the temperature and the melting process. However, these technocratic inventions as towing icebergs are today available, and it is a matter of planning no longer if this would be possible. In picture 1, the boat on the picture illustrates how in the North Atlantic towing boats are used to protect the oil rigs from being hit by an iceberg.

Findings in the literature shows that before the 21st century, geographical distances did matter as much as the technological advancement of boats to tow. Today, it is possible, and this creates a certain problematization of how geography is affected by technological interventions that eliminate the preconditioned factors of societies living in dry and arid terrains to become water secured. Icebreakers and towing techniques are making societies living under physically water scarce conditions, such as Saudi Arabia to secure their water access. For instance, one iceberg that is 30000 x 1500 x 600 feet could contain as much as 20 billion gallons of fresh water. If there would be one million people using ten gallons of water per day, then this could care for the needs of one million people for more than five years (Brain, 2018). As these findings suggest, if technological interventions develop to such a degree that it is easier to tow icebergs in this size, people in dry and arid regions and with plans such as Prince Mohamed Al-Faisal could be realised.

5.2.3 Dry, arid and desert conditions limiting development?

Regarding the question of whether countries are determined to become underdeveloped because of the lack of access to physical water sources such as rivers, lakes or groundwater. This section will now illustrate how the case of Saudi Arabia works as an example to counter argue the environmental deterministic position where the facts are based from the findings in the textual analysis made and from the observations at SIWI WWW.

No water, no development that is a statement that was observed several times at the SIWI WWW 2018. The question then if countries that have no access to lakes or water streams are

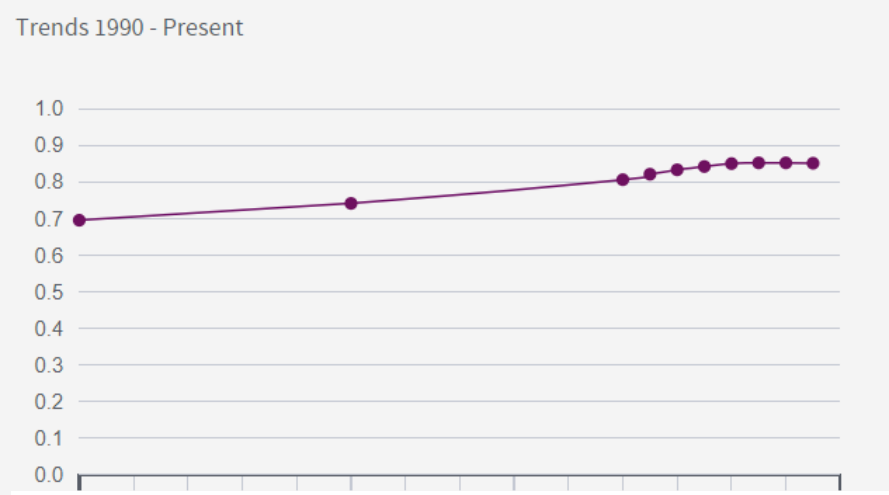


Table 3. The HDI index is changing over time from 1990 to 2018. (Source: UNDP)

determined to face water insecurity? According to the human development index (HDI) in 2018, Saudi Arabia ranked 38 (UNDP, 2018). Looking at table 3, we see an illustration of HDI changing over time, from 1990 to 2018. What this tables tells us is that Saudi Arabia is not on its way to become underdeveloped, rather the opposite. However, a definition to what development in this case does not show more than the variables of health, education and the standard of living. For this reason, the table 3 by itself, may not be a suffice indicator of development. What we do see in Table 3 is that since 2014 the graph has not stagnated since the 1990s. For this reason, this table suggests that there is no trend in the underdevelopment of Saudi Arabia despite its geographical location lacking rivers, lakes and minimal access to groundwater in desert terrain. For a country to be rated according to the UNDP HDI index as underdeveloped it has to be under the 0.7 indexes, which according to the table 3 Saudi Arabia is not.

6. CONCLUSION

This study has answered the questions on what the factors are that explains the water scarcity conditions that per se are not geographically pre-conditioned. The factors found in the textual analysis and at the observations at SIWI WWW was that water management often is the significant factor for water scarcity. The examples used to show this was the cases of the leaking water pipes. For instance, as John Briscoe (2015) defined water security that it needs to be a covering the dimensions of water management and governance where the infrastructures are developed and sustained so that leakage is prevented. These factors as Briscoe mentions in the literature are not depending on climate or geography, instead it is up to the management and governance institutions to mitigate the water-related risks of leaking pipes. For this reason, the argument holds that water scarcity is not only a problem of geography it is a management issue. The example of leaking water pipes also shows how relevant technologies are to the water sector and creates water security, for this reason, the second research question was also answered in this research

The ways that the technological interventions have created water security for societies living in water scarce conditions that are somewhat determined by their geographical location is explained in the case of virtual water and towing icebergs. How trading with produce that initially needs a lot of water and contains water creates a security for dry-regions through trade. Now, when it comes to the iceberg towing it is a practical case example of how the development of technologies assists the movement of ice and potential drinking water for communities. This example is not sufficient to illustrate the whole advancement of technologies but it is enough to use as one counterargument of water scarcity being determined by geographical preconditions. As time and space becomes more compromised due to technologies, this also affects the geographical preconditions as shown in the literature findings.

The third research question of why Saudi Arabia is not determined to become underdeveloped because of their physical access to water. This was shown by the findings in the literature, where the examples of desalination industries show how technologies, again, is the solution for dry

and arid landscapes such as Saudi Arabia has. For this reason, the argument of environmental determinism and that dry and arid landscapes face their futures as underdeveloped is not true.

6.1 Discussion

The findings from this research has shown that there are other factors and variables that affects water security rather than pure geographical conditions such as dry and arid landscapes. The reason for this is because technologies has compressed both distances and time, also making techniques such as iceberg towing available. For this reason, water security is strongly connected with the access to technologies, which in turn, becomes both a question of who has access and under what conditions is this person/group willing to share the benefits of these technologies so that water is equitably shared in their communities.

6.2 Suggestion for further research:

More research is needed as the case of Saudi Arabia is not sufficient to explain the answer to whether environmental determinism is the root cause for water scarcity and its correlation with underdevelopment. The result which was found in the literature and at the conference shows that there are reasons to continue investigating in how water scarcity can be mitigated through management and institutions, such as preventing the leaking pipes both for clean and untreated water.

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