SOLAR STILL

THE SCRIPT OF OUR DESIGN

"Designing a sustainable solution to hinder the transmission of COVID-19 in refugee camps in Greece"

Femke Zijderveld
Freek Vercammen
Iordan Nikolov
Isaac O'Sullivan
Kayla Veldkamp

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Class of 2023
Technology, Liberal Arts & Sciences
University College Twente

Abstract

To create a solution suitable for our stakeholders, we had to analyse the context of their lives. This solution and its design script needed to be based on scientific insights regarding the design of technology in crises. We, therefore, set a theoretical framework of this project involving the Capability Sensitive Design Approach and its combination with the Sustainable Development Approach by Lessmann (connection established over Capability Approach).

Considering the findings of these approaches with the focus on our stakeholders, we integrated our research into the Value Sensitive Design by van de Poel. Another method that was broadly applied in the scope of the primary stakeholder analysis was the empathy mapping. Based on our results, we derived a design script of our product that involves design requirements and intended design functions. In the design script of our solution, we discuss other concepts relevant to our prototype too - intended and unintended interactions of the product as well as its hard and soft societal impacts and frugal innovation as a crucial segment of this section.

We also considered different standards and regulatory policies to ensure the quality of our design. These include the guidelines for drinking-water quality, in their 4th edition, incorporating the first amendum from the World's Health Organisation, the Sphere Minimum Standards, the goals for sustainable development by the United Nations and engineering standards for quality control provided by the International Standardization Organization (ISO).

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Introduction

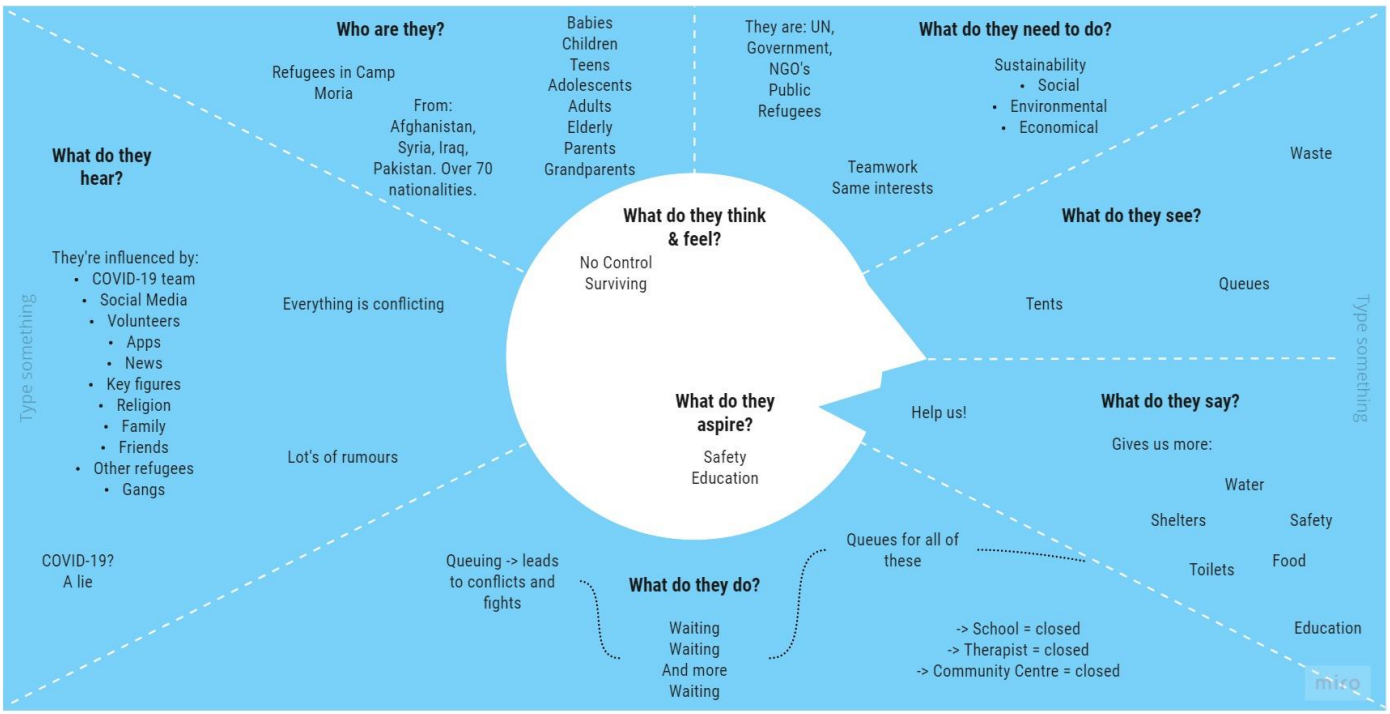
In the following sections, we would like to define the script of our design and elaborate on our conscious decisions why the script will take the particular form provided in the next paragraphs.

It is important to remember that, while the wellbeing of our main stakeholders has been our primary focus in all of our design choices, it is impossible to predict with perfect accuracy how our product will affect them and their environment. Technology plays a central mediating role in the relationship between people and their environment. For this reason, it is essential that we not only focus on intended interactions but take a critical stance on what the unintended interactions may be. In the upcoming sections, we will give an overview of the design process we have gone through over the past few weeks. Additionally, we provide the requirements, functions and norms that have guided us and will continue to guide us in our design. But firstly, we will make an attempt to see through the eyes of our stakeholders to understand their needs better.

Empathy Mapping

A very useful mechanism to understand our stakeholder's needs, thoughts and wishes as well as possible is to create an empathy map.

The empathy map is a way of conducting a stakeholder analysis by describing the situation of stakeholders. By capturing the user persona, it can help bring across knowledge to other team members, who might be less involved in the research regarding stakeholders. Upon that it creates an easy understanding for non-team members. Lastly it can provide guidance in the decision-making process, since it easier to distinguish what is important and what not. It specifically helped us as a team to discover the things we were still unaware of and create an understanding of how we can make a meaningful impact.



Within the empathy map, several questions are answered, these include:

Who are they?

What do they need to do?

What do they think and feel?

What do they do?

What do they say?

What do they hear?

What do they see?

Who are they?

This question is important to illustrate the background of the stakeholders. In our case their ethnicity, age groups and gender. Here we figured that our stakeholder group, the refugees in Greek camps, is really diverse (The Guardian, 2020). This means that our solution should not in any way exclude the most represented age groups. This is why we included it in the requirements.

What do they need to do?

The second question aims to address what the stakeholders themselves can do. We decided to incorporate some important other groups as well, since they have a major influence on the freedom of our stakeholders. These are the government, the NGO's (for instance the United Nations Refugee Agency) and us. We also saw that these four groups of people, including us, can together strive for reaching sustainability. For

this, several things are needed, such as proper regulations. Regulations might influence the freedom of our stakeholders, which might impact the appropriateness of our design.

What do they think and feel?

This question is important to understand the motivation of our stakeholders. It is very relevant to have a deeper understanding of one's motivations, since our stakeholders must have a motivation to use the final product. If they have no motivation to use a product or service, they will never adopt it into their lifestyle. Refugees mostly seek freedom, safety (Emmanouilidou, 2020) and if possible, aspire education (Theirworld, 2020). Safety comes in various forms, from a shelter above their heads, to no conflicts and enough water and nutrition, all things that do not always apply to a life in a Greek refugee camp.

What do they do?

This question will guide us through the daily life of our stakeholders. The answer illustrates the situation our stakeholders have to go through every day. This was very important for our decision making when designing a solution, since we became aware that queuing (Human Right Watch, 2020) is the most important daily activity. In times of COVID-19, this is a controversial thing to do. This realisation led us to the conclusion that we wanted to design something that can reduce the queuing and thus the spread of COVID-19. This is why the reduction of lines is also included in the requirements.

What do they say?

The fifth question also provides a deeper understanding of what the stakeholders need from their point of view, instead of from a more general perspective. It is important to consider both, since the problems of the stakeholders might be caused by situations, they are unaware of. This can also happen the other way around. We identified the need for safety, water, food, sanitary and education (Human Right Watch, 2020). Interesting is that they queue for nearly all of these needs. This is why we made the decision to combine the reduction of queuing and the need for water. Hence, we can come up with something that is important to the stakeholders themselves, while also having an influence on the bigger picture. Therefore, we included requirements that contain both the reduction of queues as well as the provision of drinking water.

What do they hear?

The sixth question is there to help us understand how to implement a solution in later stages. We need to get an understanding of where the information comes from and how the refugees are influenced. If we have a thorough understanding of this process, it will make it a lot easier for us to get the refugees to adopt our design.

What do they see?

This question is important to understand the viewpoint of refugees and how they could see a change in their world when our design is implemented. Because if they do not perceive a change in the world by using a product, they will be less motivated to adopt it. In order to give them a product that actually makes a difference, it is

important to understand the world of a refugee as well as their perspective at this moment, while also having an idea of how their world would change if a certain product is implemented.

All of these questions will be answered more in depth in our deepenings, and thus end up in deliverables. For some of them, more information is still needed to fully understand the situation, however these are more with regards to the implementation of our design. Which will become more important when designing the product itself in the coming phases.

Direction of the product

After we identified basic needs and capabilities of our stakeholder (see stakeholder analysis), we will continue by defining the functional and non-functional requirements of our design based on user capabilities. The proposed solution for which we designed our script is a solar still that distils seawater. The components of this design are visually represented in fig. 1.

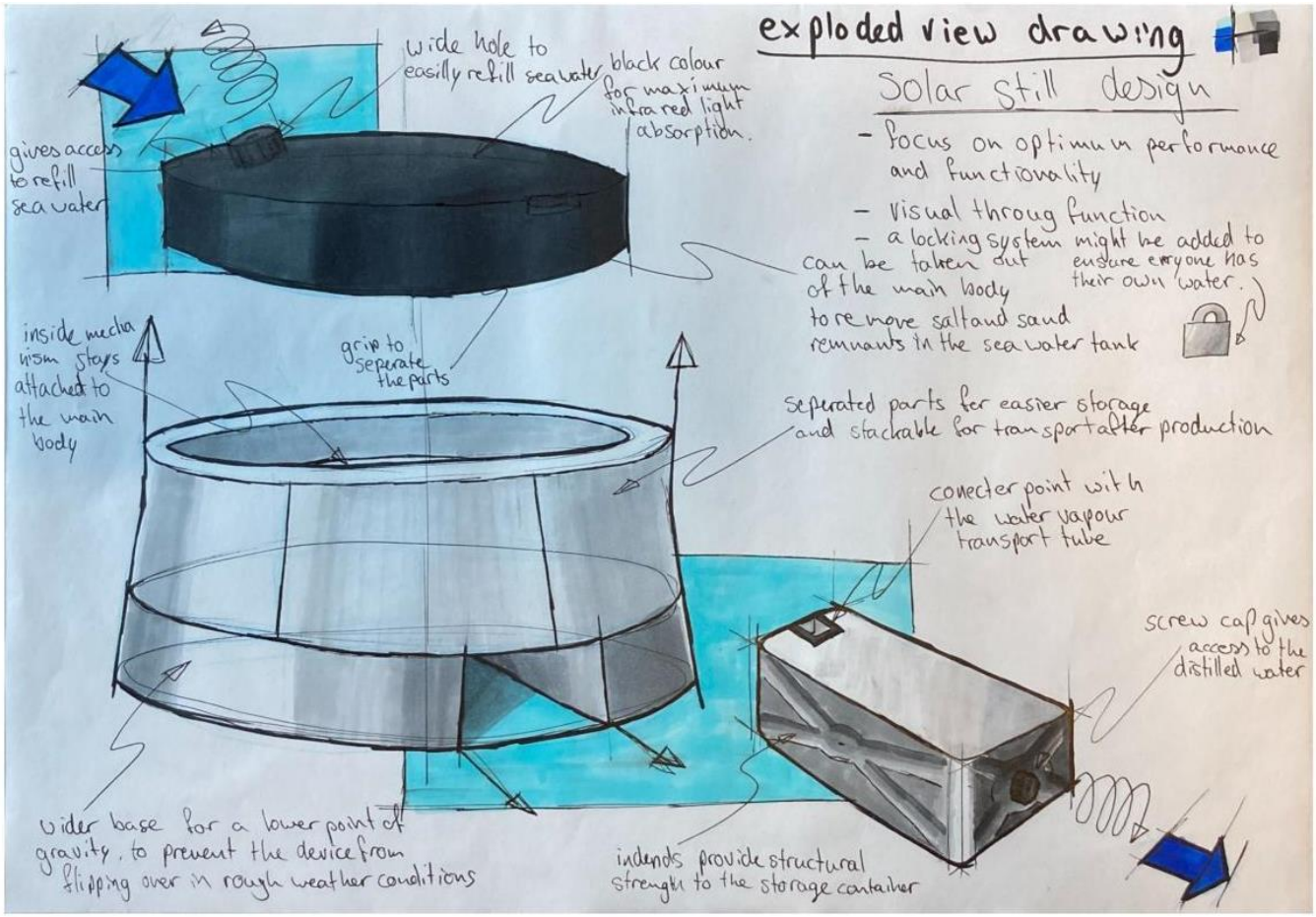


Figure 1. Exploded view of the Solar Still

Requirements

Inspired by the capabilities mentioned in our context study, these are the requirements (R) our product has to fulfil:

Requirements for Life and Bodily Health (Capability No. 1)
The product shall enable users to drink purified/distilled water The product shall reduce the time refugees spend waiting in lines by 50% or more The product shall reduce the salt level of seawater to levels stipulated by GDWQ guidelines
Requirements for Other Species (Capability No. 2)
At least 80% of the product shall be biodegradable. The production process shall be at least 80% greenhouse gas neutral 100% of the plastic that is used during the manufacturing process shall be recycled The product can be packaged with less than 20% wasted space so it can be transported in bulk The product shall account for cultural and individual differences (language, ethnicity, country of origin, etc.) and shall allow every user to navigate the product.
Requirements for Control over one's Environment (Capability No. 3)
The product shall be affordable to be manufactured in bulk, purchased, cleaned and repaired.

The product can be packaged with less than 20% of wasted space so it can be transported in bulk

The product shall distil 140 litres of seawater/be used four weeks before the distilled water storage tank needs to be rinsed.

Functions

Based on the previously formulated requirements, our list of functions states that our product will:

- Admit seawater to storage tank A - seawater storage tank.
- Contain seawater in storage tank A without leakage.
- Evaporate seawater with solar energy.
- Contain water vapour in storage tank A without leakage.
- Transport water vapour into storage tank B - distilled water tank - through heat flow and pressure difference.
- Retain impurities such as pathogens, sand and crystallised salts in storage tank A.
- Condense water vapour in storage tank B.
- Contain distilled water in storage tank B without leakage.
- Stop environmental contaminants such as sand, leaves and other debris from entering storage tank B.
- Uncover/remove storage tank B when necessary.

Definitions (Terminology relevant to the defined requirements.)

Term	Definition
R	Transmission ability rate of a disease from a person to others
Group-based education	Students go to a specific location with the purpose of receiving education in a group setting
Affordable	This depends on the specific product architecture and cannot be fully defined right now. Once that is clear affordability will be specified as the capital cost and the operating cost per liter.

Intended interactions

As previously stated, the main outcome of our product will be to allow refugees to avoid queuing for clean water by providing them with personal water purifying devices. This would make it easier for refugees to stay socially distanced as much as possible while also receiving the resources they need. This goal will be facilitated by functions (1) to (10).

Our product will also allow the refugees to rinse storage tanks A and B themselves when necessary. This interaction will be facilitated by function (1) and (10).

Refugees should not need any prior training or expertise to be able to do this without damaging both storage tanks.

The use case diagram on the next page visualises the intended interactions that our product will have with the user and the environment.

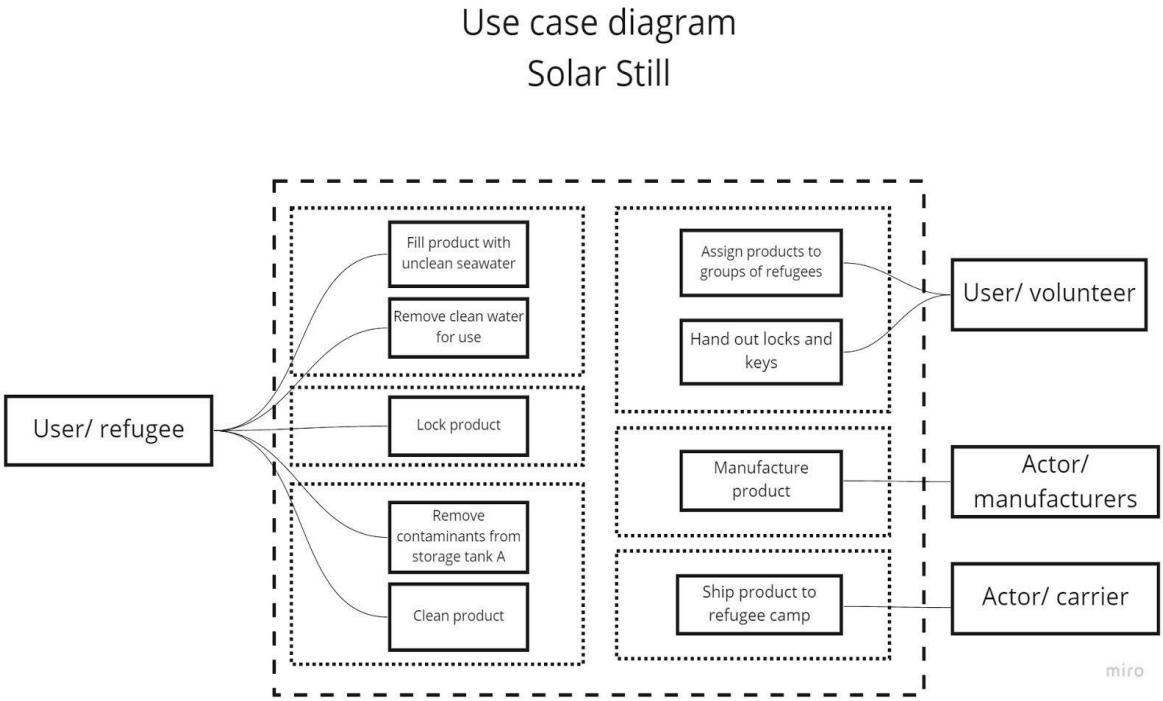


Figure 2. Use Case diagram.

Unintended interactions

After considering all intended interactions, we have to account for another type of interactions which can indeed influence how well our product considers the stakeholder's capabilities - unintended interactions. People do not always use a product in the way it is supposed to be used. For instance, this can happen when there is a lack of knowledge on how to use the product. Sometimes, external factors are not taken into account when designers develop a product. These circumstances could cause an incorrect use of it and put the user at risk.

It is impossible for a team of designers to be aware of all unintended interactions. However, the most important pitfalls can be recognised upfront after an analysis of the potential use of the product, e.g., with a use-case-diagram. These pitfalls can, for example, be solved in the final design - minimising the exposure of the user to a possibly dangerous use. The most important unintended interactions we identified are:

Refugees can put themselves into unsafe situations attempting to collect seawater

Refugees can use our product incorrectly (for example by not rinsing storage tanks A and B) and consume unclean water or use it to wash their hands.

Refugees may queue to use the product, which may cause another source for transmission of communicable diseases (far less queuing than is currently happening however).

Norms

After we define our functional requirements, functions, intended and unintended interactions, it will be important to ensure certain minimum standards of our design. Hence, we will work within the framework of different policies, regulations and codes.

Our solution involves the provision of access to drinking water to our stakeholder. Therefore, we considered the guidelines for drinking-water quality, in their 4th edition, incorporating the first amendum from the World's Health Organisation to be of great relevance (WHO, 2017). In response to this, one of our requirements has to ensure users' access to drinking water that meets the GDWQ quality standards:

Guidelines for Drinking Water Quality by the World's Health Organization			
Health-based targets			
Type of target	Nature of target	Typical applications	Notes
Health outcome	Define tolerable burden of diseases	High-level policy target set at national level, used to inform derivation of performance, water quality and specified technology targets	These Guidelines define a tolerable burden of disease of 10^{-6}DALY per person per year

	No adverse effect or negligible risk	Chemical or radiological hazards	Derived from international chemical or radionuclide risk assessments
Water quality	Guideline values	Chemical hazards	Based on individual chemical risk assessments
		Microbial water quality targets are not normally applied	Escherichia coli is used as an indicator of faecal contamination and to verify water quality
		Radiological water quality targets are not normally applied	Radiological screening levels are applied

Performance	Specified removal of hazards	Microbial hazards (expressed as log reductions)	Specific targets set by water supplier based on quantitative microbial risk assessment and health outcome targets or generic targets set at national level
		Chemical hazards (expressed as percentage removal)	Specific targets set by water supplier based on chemical guideline values or generic targets set at national level
Specified technology	Defined technologies	Control of microbial and chemical hazards	Set at national level; based on assessments of source water quality, frequently underpinned by

			established or validated performance of the specified technology (e.g. requirement of filtration for surface water).

Our stakeholder lives under extreme conditions, so next to the guidelines listed above, we decided to incorporate other standards too. They must ensure that all the previously mentioned guidelines will be met in a crisis situation - like currently living in camp Moria. The Sphere Minimum Standards (2018) provide a viable framework for this scope. These standards aim at securing a life in dignity for every human being and especially for those living under extreme conditions and crisis situations.

We will focus on the chapters Water Supply, Sanitation, and Hygiene Promotion (WASH), particularly targeting to fulfil the following regulations (Sphere Association, 2018):

Sphere Minimum Standards (SMS)	
Sphere Minimum Standard Number[1]	Description
Hygiene promotion standard 1.1[2]	People are aware of key public health risks related to water, sanitation and hygiene, and can adopt individual, household and community measures to reduce them.
Water supply standard 2.1: Access and water quantity[3]	People have equitable and affordable access to a sufficient quantity of safe water to meet their drinking and domestic needs.
Solid waste management standard 5.1[4]	Solid waste is safely contained to avoid pollution of the natural, living, learning, working and communal environments.

[1] Subscripts provide response of the previously defined requirements and functions to the specific standards.

[2] Our product's functional requirements and design functions will indeed fulfil this standard because our product shall help our stakeholders reduce a public health risk, namely the spread of COVID-19.

[3] Our product aims to ensure the access of our stakeholders to drinking water by desalinating and disinfecting seawater through vapour and pressure mechanisms with solar energy. Thus, it will provide our stakeholders with a sufficient amount of water on a daily basis.

[4] Our solution has to be biodegradable for at least 80% of its components and all plastic components of the product shall be recyclable. Hence, we will create an environment free from solid waste (regarding our solution).

Solid waste management standard 5.2[5]	People can safely collect and potentially treat solid waste in their households.
Standard 6: WASH in healthcare settings (specifications)	*Drinking water quality at point of delivery* Minimum: 0.5–1mg/l FRC *Quantity of safe water available* Minimum: 5 litres per outpatient per day
Standard 6: WASH in healthcare settings	All healthcare settings maintain minimum WASH infection prevention and control standards, including in disease outbreaks. Technology shall increase water quantities according to disease type, risk and needs.

Our solution has to be affordable and should be easy to navigate by any of our stakeholders. Therefore, by creating a cheap solution, our product will meet the standard above in terms of the quantity of the product the stakeholders will have at their disposal.

In our research, we also realised that it is challenging to find and set universal standards for creating a sustainable solution which will avoid Moria of adding more waste to the thousands of tons of plastic around the entire camp zone (Squires, 2017). Therefore, we created the following requirements which our solution shall fulfil,

[5] This is a standard we will meet too, since we set an ergonomic requirement of our product to be free of pain and that it shall be easy to use. Combined with our requirement of the product to be recyclable, we will indeed account for this standard.

according to Lessmann's model (2013) of sustainable development based on the capability approach:

At least 80% of the waste from our solution shall be biodegradable.

The production process shall be at least 80% greenhouse gas neutral

All plastic that is used during the manufacturing process shall be recycled.

The product can be packaged with less than 10% of wasted space so it can be transported in bulk.

By fulfilling these and previous requirements, we will be able to meet the following sustainable development goals formulated by the United Nations:

Goal 3. Ensure healthy lives and promote wellbeing for all - at all ages. Goal 6. Ensure availability and sustainable management of water and sanitation for all. Goal 10. Reduce inequalities within and among countries. Goal 11. Make cities or other human settlements inclusive, safe, resilient and sustainable. Goal 12. Ensure sustainable consumption and production patterns. Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems. Sustainably manage forests, combat desertification, and halt and reverse and degradation and halt biodiversity loss	
Goal number	How does the product meet the sustainable development goal?

3	By hindering the transmission of COVID-19
6	By ensuring drinking water for the refugees
10	By providing the refugees with water broadly available to the Greek population
11	By creating a sustainable way of accessing drinking water, the settlements are made safer and more resilient against disease.
12	By using solely solar energy, the produced distilled water is ecologically sustainable.
14	By creating a product that is highly durable and biodegradable by 95%, the design ensures the conservation of the sea next to the camp and its ecosystem. On the other hand, using the virtually limitless water resources of the sea are a sustainable way of accessing drinking water without polluting the environment.
15	By being biodegradable for up to 95% and highly durable, the design will not pollute the surrounding terrestrial ecosystems. Moreover, it will reduce the consumption of bottled water and the plastic waste will be reduced in the area over time.

Finally, we need to set engineering regulation standards for our design solution. According to the predefined design functions, we decided to ensure technical quality control of our product that is derived from the standards of the International Standardization Organization (ISO) as follows:

International Organization for Standardization (ISO)	
ISO Standard Number	Description
ISO 9001:2008	Quality management systems - Requirements
ISO 9060:2018	Solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation
ISO 9459-1:1993	Solar heating - Domestic water heating systems - Part 1: Performance rating procedure using indoor test methods
ISO 9459-2:1995	Solar heating - Domestic water heating systems - Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems
ISO 9459-5:2007	Solar heating - Domestic water heating systems - Part 5: System performance characterization by means of whole-system tests and computer simulation
ISO 22975-1:2016	Solar energy - Collector components and materials - Part 1: Evacuated tubes - Durability and performance
ISO 22975-3:2014	Solar energy - Collector components and materials - Part 3: Absorber surface durability

ISO 22975-5:2019	Solar energy - Collector components and materials - Part 5: Insulation material durability and performance
ISO 14001:2015[6]	Environmental management systems — Requirements with guidance for use

[6] A regulation relevant to the sustainability aspects of the design

Conceptual connections of theoretical framework elements

To lead a good life, our stakeholders and everyone else are dependent on technological means and the way they shape our lives and environment (Gonzalez, 2020). Therefore, we integrated the Capability Sensitive Design Approach in our framework. This helped us realise how our product can interact with our stakeholders and vice versa. These interactions are important as they show how our product could potentially impact our stakeholders and their environment. The Capability Sensitive Design Approach has sparked a discussion about the intended and unintended interactions our design might have.

The Capability Sensitive Design is directly linked to the concept of design appropriateness. But what does design appropriateness mean and when is a design appropriate? Any design needs to be suitable for the individual intended to use it and for the purpose it has to fulfil. It should also be fitting to its environment - it should not be damaging to the surrounding world and should not put the intended user at any disadvantage - be it of physical, mental or other nature of discrimination. Design appropriateness is the fundamental principle of our product and all upcoming concepts serve the purpose of creating a design that is appropriate to both our stakeholders and their (ecological, social & mental) environment.

We considered a needs-based capability approach to derive the required functions of our product. In this process, we considered sustainability aspects, standards, norms and regulations, and concepts like hard and soft impacts as well as frugal innovation.

In our context study, we have identified the main needs of our stakeholders and how these relate to their capabilities. We also bridged the goal of sustainable development to the capability approach model. We have based these relationships on the theoretical framework developed by Lessmann et al. (2013).

Fig. 3 conceptually connects the types of impacts our product has on the stakeholders' environment. Specifically, we hypothesised that the soft and hard impacts of our solution are linked to many aspects of sustainability relevant to our design (see fig. 3).

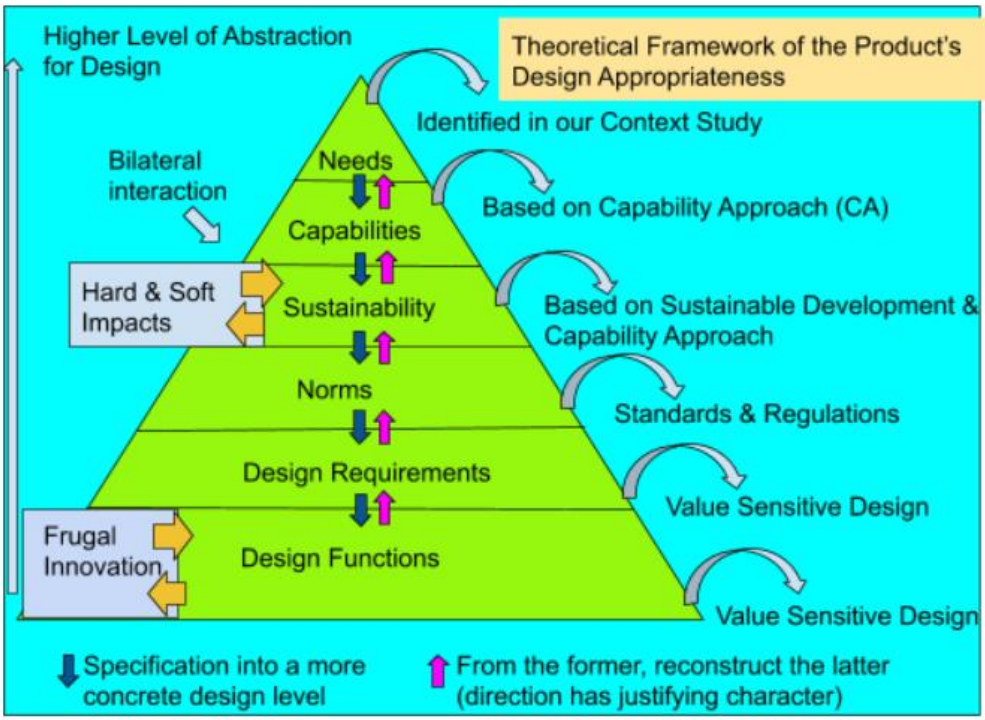


Figure 3. Theoretical Framework of the Solar Stills Design Appropriateness.

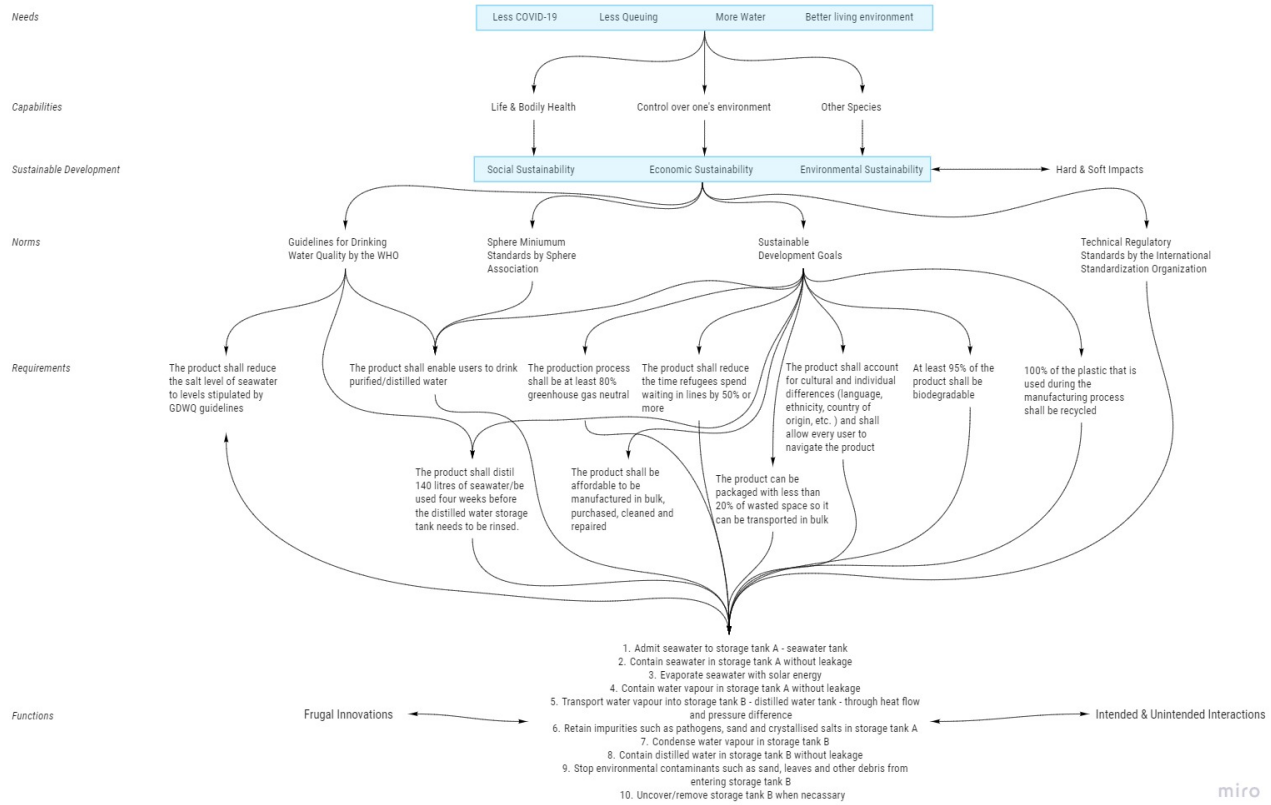


Figure 4. The Extended Theoretical Framework

From this step on, the necessary policies and regulations identified in the previous paragraphs (summarised under the term 'norms') filter every decision for our solution and how it will meet its technical requirements and goals for sustainability (Conelli, 2007). Using the Value Sensitive Design by van de Poel from 2013 (second half of the Capability Sensitive Design), we can clearly link the capabilities we design for to the functional requirements of the product. Lastly, inspired by these requirements, we derive the functions of our product. The functions, on their side, have carefully been defined in light of the insights of frugal innovation considering the dimensions, "substantial cost reduction", "concentration on core functionalities", and "optimised performance level."

All of these different elements of design ethics are connected on a grand scale in our theoretical framework - the design appropriateness of our solution and the Capability Sensitive Approach (a concept created by merging the Value Sensitive Design with the Capability Approach).

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