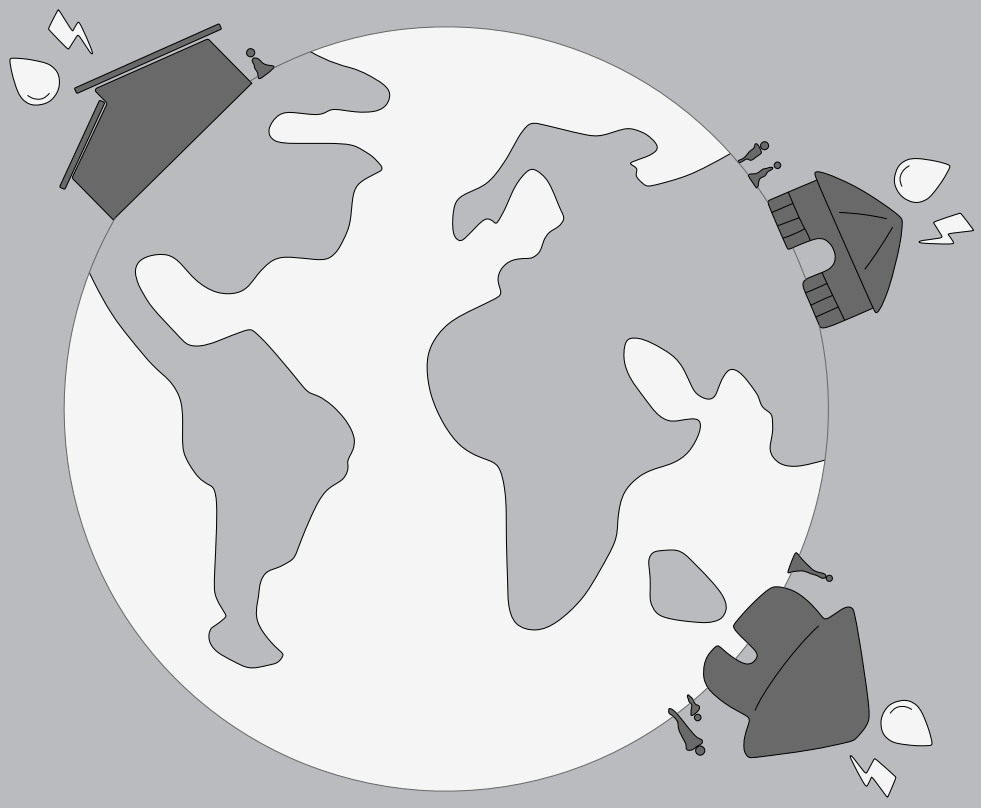
REDESIGN DISASTER:



WATER & ENERGY HUB.

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1.1 Information

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Project: MSc Graduation Project 2020
University: Delft University of Technology
Faculty: Faculty of Architecture
Track: Building Technology
Studio: Sustainable Design Graduation Studio
Topic: Redesign Disaster: Water & Energy Hub.
Mentors: Main mentor: Dr.ing. Marcel Bilow
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1.2 Problem Statement

90% of Beira, the seaport city of Mozambique, has been significantly destroyed by Cyclone Idai leaving more than 250,000 people without access to basic living needs.

WHO estimates that **more than billion people around the world have limited or no access** to clean drinking water and most of these people come from rural areas where the low population density makes it difficult to build typical water networks. A lot of Mozambicans must use unsanitary water for living. UNICEF reports that **only half of the country's population (13.7 million people) has access to drinking water.**

Around **610 million people in Africa have limited or no access to electricity** and cuts from the national grid occur on a daily basis in most of the African countries. The average electricity energy consumption per capita in sub-Saharan Africa (excluding South Africa) was only 153kWh/year in 2009. To compare, this was only one-fourth of the consumption in India and just 6% of the global average. (Monari, 2011).

According to the World Health Organisation, diseases caused by **unhealthy sanitation cause two million deaths globally each year**. Effective sanitation is one of the most crucial humanitarian issues in Africa today. UNICEF reports that due to lack of sanitation facilities **40 percent of Mozambicans still need to defecate outdoor**. The rural population relies on poorly built and maintained onsite sanitation facilities. During periods of heavy rainfall, **untreated wastewater is released into the environment** polluting both surface and groundwater sources (WSUP, 2019).

Most of the small-scale objects are not built to suit the dangers of extreme weather events occurring more frequently and with increasing intensity in the Beira region. **Lack of proper foundations, weak building walls, and poor roof-wall connections** do not provide resistance to strong winds and rains causing huge damage to the entire community.

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1.3 Research Objective

Small scale, sustainable building supplying drinking water and energy to the affected community.

Research from 2015 (The World Bank) shows that **half of Mozambique's population lives without access to freshwater**. The main goal of the project is to design a **low-tech solar-based water purification system and provide clean water and energy for 50 people community of rural Africa**.

A detailed **construction manual of the small off-grid water and energy production hub will be the final product** of this research. The building will be designed with the use of locally available materials. It will include **sustainable, healthy sanitation system, and will be designed as a pilot public facility**. Water will be reused by a building itself. Blackwater, after being treated properly, will be used for biogas production, then turned into compost for agriculture and released to the environment in a controlled way. Both water and energy production components will be integrated with the hub's roof. Due to the large footprint required for the systems, it will be designed as **a free-standing structure with the open-space adaptable floorplan**.

1.4 Research Question

How to supply drinking water and energy for small rural communities of Beira with the use of a low-tech, solar-based decentralized system?

The water purification system elaborated in this research will require 200 square meters to be able to produce 1600 liters per day (32 liters per person), while the energy production system consisting of 30 PV panels will need additional 50 square meters (installation with a capacity of 13300kWh). It is clear that combined 250 square meters are more than an area needed for the building itself. Sanitation and additional functions for the target group will require around 50 square meters, thus part of the production system will be designed as a free-standing roof structure, giving not only shade but also freedom of hub adaptation for local functions and public space. From this, a question of **how to combine all systems with the building for proper functioning** is posed. The building will need to deal with the characteristics of the region and the social and economic situation of the targeted community. Considering specific weather conditions in which building will be meant to operate a question of **how to properly design main building components connections (foundations-walls-roof), that are capable to withstand strong wind and rain** arises. The hub is meant to be a project that provides solutions to broadly understood problems of rural communities, **it needs to be universal, reproducible and simple to construct by local people using locally available materials**, like bamboo culm. Also, this research will address the question of **how to properly design an on-site, decentralized, and sustainable system to protect the environment and natural resources, and release waste in a controlled, safe way**.

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1.5 Aspects

What is the relationship between research and design in the graduation project?

In the track Building Technology, technical research plays one of the most important roles in each project. Based on the research conducted in the first phase of the graduation project, the final design was reached by linking partial solutions into a spatial strategy. In Phase 1 of my report, extensive research into the economic, social, and cultural situation of the site region was made. Research involves the process of planning and elaborates on many complex problems, like climate change or living conditions in African rural areas. During the research phase, I received a comprehensive overview of the situation in Beira as well as existing technology related to my topic. The research helped me to define ideas for testing and systematize the available knowledge necessary in the second phase of the project - design. As a result of improvements and mentors' feedback, I see a significant difference between where my research started and where my final design ended. The first ideas were confronted with each other and often slightly changed the point of view, design conditions, and programme. In the graduation project, the study of design and the process of output production occurred simultaneously. Design involves a deep investigation of the Phase 1 conclusions and explores various ways of reaching goals and answering research questions. Part of my design involves technology testing meant to push the project's theoretical and conceptual boundaries and turn into final product design and is based on research findings. Both phases Design by Research and Research by Design played a significant role in making creative jumps in thinking and solving problems.

How is the graduation topic positioned in the studio?

In the studio Sustainable Design Graduation Studio students are allowed to choose own topic. My topic was created directly as a result of the prevailing world circumstances and information that came to me when making decisions about graduation direction. The reason was last year's climate events having a catastrophic impact on eastern Africa. My topic includes the development of an off-grid water production system to accelerate recovery after the natural disaster occurred in March 2019 and to improve living conditions in poor regions. Circularity in the built environment is becoming more widespread and is crucial in reducing the building industry's

negative impact on the environment. Circularity in my project not only is related to used materials, components and joining techniques but also to water management. The facility is meant to be self-sufficient with a neutral impact on the surrounding. Following the rule of 'Reduce, Reuse, Produce' the water within the building is designed in a closed loop with maximization of reuse while ensuring high quality of fresh water for life. Also, the goal is to teach the local community weather-resistant building techniques with the use of local materials and resources only. The focus on fabrication aspects and mock-up testing fit the project between Architecture and Engineering. The project aims to help people in low-income African rural areas, which makes this topic in-line with the spirit of the Sustainable Design Graduation Studio.

What is the relationship between the methodical line of approach of the studio and the methods used in the graduation project?

The Building Technology methods focus on the correlation between Architecture and Engineering. Reliable scientific and technical research provides specific requirements for the design. The thesis is mainly supported by extensive literature research. Sources were cross-checked with each other to gain a coherent image of the topic. The final product of the graduation project, a detailed construction manual is designed to let the target community acquire the knowledge. Of course, it is expected that a final design is delivered at the end, but the manual is seen as a tool for local people as the academic resources represent tools for students. In both cases, the goal is teaching and skills improvement. This is why the entire building and water system are designed as modular to give and show its versatility and multiple implementations. If local people will follow the manual guidelines they can easily use it for building a long-lasting architecture of any function equipped with off-grid water, energy, and sanitation systems. The final design presents the public facility serving all residents of the local community but the project can be very easily turned into housing units, schools, or clinics.

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What is the relationship between the project and the wider social context?

The main target of the project are low to mid-low income African rural areas. A pilot project can teach the local community how to build houses that are resistant to extreme weather conditions using locally available materials. It will reduce the need for frequent building repairs, saving both money and time. In the light of limited available fresh water resources and water scarcity in African rural areas, the growth of alternative cleaning water systems and techniques is crucial. Furthermore, the innovative design with the use of low-tech solutions shows the strength of research both within and outside the academic field. In 2015, UN countries signed up to a commitment to provide electricity to every household on Earth by 2030, however, current statistics show that it will not be possible to reach that goal in such a short time. This project aims to make both authorities and rural communities aware of problems they have to face and show a possible solution The project presents a mini-grid solution as one of the most beneficial for providing clean water and electricity for low-density rural areas, where the extension of national grids is not viable. Moreover, decentralized systems avoid the problem of cuts from the main grid, ensuring a less intermittent supply, which has a positive impact not only on households but also on local businesses, public facilities, and clinics.

To what extent are the results applicable in practice?

Parallel to the theoretical part of the project, the reality, moreover, the possibility of immediate implementation of the building was taken into account. Each aspect of the project was considered in detail, both in the context of the materials used, their availability or price, as well as logistical problems related to the conditions prevailing in the region. From the first day of work on the project, I put a lot of emphasis on the possibility of building the facility and water production system. For this purpose, I was constantly in touch with non-government organizations working in the field to receive advice and help. Bearing in mind that this part of the project will not be considered in the context of assessing my work on the graduation project, I was very keen to make the project as realistic as possible. Examples of the work of our faculty students from earlier years inspired me to attempt to organize measures, capital, and companies that could be responsible

for the construction and operation of the facility. Unfortunately, when started, I did not expect how big and extensive this process is. The theoretical part requires a huge amount of work to be solid and reliable. The high rate of changes in the design hinders the simultaneous development of the product and attempts of its immediate implementation. Only the construction of a 1-1 mock-up allows reliable tests and gives the possibility for improvements. However, I stay in touch with a company that deals with financing and building affordable houses in Mozambique on a daily basis and is interested in my project. Nevertheless, work on the implementation of the facility in Beira has a chance to occur only after finishing the graduation process. The fact that a significant number of African communities live in remote and rural areas, means that self-sufficient and off-grid hub producing clean water and energy has a very good chance to spread and be widely implemented into practice. For this purpose, after graduation, the project will be published and if necessary, an open-source platform with a detailed construction manual will be created.

How does the project affect the built environment?
Building Technology is seen as a binder between architecture and engineering, technical innovation can become a starting point for architectural strategy and design. The project aims to use an innovative low-tech solution and introduce it as a utility product for a small rural community, providing it with better living conditions and the possibility of faster development. The project is based on extensive technical research and existing case studies. It scales the technical, solar-based solution of providing clean water in a survival situation to a building scale, a structure that can daily serve up to 50 people, improving their quality of life. The project can change the poor situation of low-income and rural areas. Furthermore, teaching local community improved construction techniques will result in a safer living environment that will be resistant to changing weather conditions caused by the happening global climate change.

Concluding thoughts.
The Sustainable Graduation Studio at Building Technology track has been a great experience. It is rare for architecture students to get experience in thinking about the implementation of their designs and testing/making it work to go beyond the conceptual boundaries. Both mentors helped me a lot to

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think deeply about the feasibility of the design. I learned that there can be a multitude of problems and challenges that can be raised in such a conceptually simple project. All aspects including calculations, designing, detailing, and production techniques were something I had to think hard about. Both research and design processes improved my English technical language standards which had an impact on how I was able to convey my ideas and points across fellow students and professors. I was encouraged to think about the business market from which I learned a lot about how a designer had to consider the production processes involved if the design is meant to be constructed for a real scenario. This helped me to realize that even the simplest objects can require critical thinking just to be realized. The CAD modeling was used during the entire process to keep an eye on all aspects simultaneously and gave me some new skills. An extraordinary situation caused by the outbreak of the Coronavirus was a challenge for both students and professors. Working from home and making all meetings online slightly reduced work efficiency and progress, however, the university was full of opportunities and the professors were full of enthusiasm. The epidemiological situation caused by Coronavirus affected the prototyping phase and caused significant delays in materials delivery, however, I managed to test the prototype on time. Although the graduation project was very demanding and required hardworking every day, overall, I am very satisfied with my studio and topic choice.