

11 SUSTAINABLE CITIES AND COMMUNITIES



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



15 LIFE ON LAND



17 PARTNERSHIPS FOR THE GOALS



8 DECENT WORK AND ECONOMIC GROWTH



14 LIFE BELOW WATER



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



13 CLIMATE ACTION

2021 ANNUAL RESEARCH REPORT

2 ZERO HUNGER



4 QUALITY EDUCATION



3 GOOD HEALTH AND WELL-BEING



IMPACT PROJECTS



Engineering for Change (E4C) was founded in 2009 by ASME, IEEE and EWB-USA with the mission to prepare, educate and activate the international engineering workforce to improve the quality of life of vulnerable populations around the world. Today, E4C is a leading knowledge organization reaching a global community of more than 1,000,000 people that believe that engineering can change the world. Currently housed at ASME, E4C is integral to the Society's mission to advance engineering for the benefit of humanity.

Engineering for Change (E4C) Impact Projects cut across geographies and sectors to deliver an ecosystem view of technology's role in achieving the UN's Sustainable Development Goals (SDGs). We investigate the relationship between engineering civil society impact, funding, and collective action. Through various methods, such as participatory research and landscape mapping, we create actionable research for funders and international development organizations.

E4C 2021 Program Management Team:
Mariela Machado, Senior Program Manager; **Grace Burleson**, Research Manager; **Marilynn Holguín Clover**, Program Coordinator; **Jonathan Kemp**, Program Associate

Published December 2021

In 2021, E4C led our largest Fellowship cohort ever: 50 Fellows from all over the globe. This year, the Autodesk Foundation collaborated with E4C to sponsor 24 of these Fellows, matching them with specific needs and practical design projects from the Autodesk Foundation's portfolio of nonprofits and startups. These savvy early-career designers and engineers from all over the world drew on their experience and expertise in Autodesk technology to provide tangible impact for their partner organizations. Projects included development or improvement of products, advancement of workflows in organizational design and Autodesk technology and targeted research.

In 2022, the Autodesk Foundation and E4C are collaborating again to provide grantees the opportunity to receive targeted technical support while simultaneously growing the human infrastructure and local capacity of the next generations of technical professionals.

Read full reports at:

<https://www.engineeringforchange.org/research/>

Read more about our Fellowship and Research Fellows:

<https://www.engineeringforchange.org/e4c-fellowship/>

To become a research partner, email: partners@engineeringforchange.org

2021 E4C FELLOWS

The Americas



Brandon Simons
USA/Korea, Autodesk Fellow

Carolina Rojas Echeverri
Panama, PC

Charles Newman
USA, PC

Damiana Pacheco-Avilés
Ecuador, Autodesk Fellow

Danna Xue
USA, Autodesk Fellow

Elisabeth van Overbeeke
Canada, PC

Emily Crawley
USA, Transportation Fellow

Emily K. Schwartz
USA, Autodesk Fellow

Erin Peiffer
USA, Expert Fellow

Francisco Plaza
Ecuador, Autodesk Fellow

Jessica Egan
USA, Sanitation Fellow

Juan Carlo Intriago Zambrano
Ecuador, Autodesk Fellow

Kyla Strickler
USA, Autodesk Fellow

Maria Nieves Brunet
Paraguay, Autodesk Fellow

Martin Ignacio del Pino
Argentina, Habitat Fellow

Matt Parsons
USA, Sanitation Fellow

Minh Nguyen
USA, Autodesk Fellow

Patrick Sours
USA, Expert Fellow

Paulo Vela
Peru, Health Fellow

Rachel Geiger
USA, Water Fellow

Sahar Shamsi
Canada, Energy/Water Fellow

Scott West
USA, Energy Fellow

Tiffanie Leung
USA, Habitat Fellow

Valentina Ospina
Colombia, Autodesk Fellow

Abdul Rashid Kanda Mussah
Ghana, Autodesk Fellow

Alaa Emadeldin Selim
Egypt, Autodesk Fellow

Ali Ghazvinian
Iran, Habitat Fellow

Buddila Wijeyesekera
Sri Lanka, Energy/Water Fellow

Dima Abu-Aridah
Jordan, Autodesk Fellow

Elizabeth Collins
Scotland, PC

Emmanuel Kinyanjui
Kenya, Autodesk Fellow

George Kelly
UK, Autodesk Fellow

Guy Mambo
Congo, Habitat Fellow

Harsh Vyas
India, PC

Joseph Bainamndi
Cameroon, Agriculture Fellow

Julian Krüger
Germany, Autodesk Fellow

Julius Mugaga
Uganda, Health Fellow

Kalimba Rugamba Nicolas
Rwanda, Autodesk Fellow

Kevin Ndeti
Kenya, Autodesk Fellow

Khaoula Trigui
Tunisia, Expert Fellow

Kimani Chege
Kenya, Editorial Fellow

Lowri Swygart
UK, Autodesk Fellow

Maajabu Alleluia Tito
Rwanda, Autodesk Fellow

Mahmoud El-Sadek
Egypt, Autodesk Fellow

Miracle Ndego
Ghana, Health Fellow

Obiora Odugu
Nigeria, Autodesk Fellow

Randolf Hackman
Ghana, Agriculture Fellow

Sally Aba Akyere Osafo
Ghana, Autodesk Fellow

Sam Butterworth
UK, Autodesk Fellow

Simeon Bunani
Rwanda, Autodesk Fellow

Tanvir Khorajiya
India, Autodesk Fellow

Africa, Asia, and Europe



PC = Program Coordinator

TABLE OF CONTENTS

2021 Impact Projects

2 ZERO HUNGER



- Kheyti** page 7
Improving DIYability of Small Scale Greenhouses
- Sanergy** page 8
Greenhouse Larvae Bed Cooling
- S4S Technologies** page 9
Design of an Automatic Tomato Cutting Machine
- University of Missouri** page 10
Advancing Towards SDG 2 in Nigeria: Food and Nutrition Security in Borno State

3 GOOD HEALTH AND WELL-BEING



- Build Health International** page 11
Masterplan Proposal for Hospital Wesleyan de La Gonâve, Haiti
- Chemonics** page 12
Climate Monitoring for Ambient Health Commodities Supply Chains
- VIA Global Health** page 13
Improving Medical Device Procurement in Africa: A Decision Support Tool for Considering Total Cost of Ownership

4 QUALITY EDUCATION



- Adaptiv** page 14
Prototype School Design for Remote and Accessible Schools in Haiti
- Colorado School of Mines** page 15
Mapping 'Engineering for Good' Career Pathways: Examples from North America
- The Ohio State University** page 16
Designing University Lab Space: Recommendations for Development Engineering Programs

6 CLEAN WATER AND SANITATION



- KickStart International** page 17
Development of an Analytics Platform for Real Time Monitoring of Water Pump Usage

Médecins Sans Frontières A Standard, Adaptable Catalogue of Water Tower Designs and Construction Typologies	page 18
National Renewable Energy Laboratory Accelerating the Advancement of Wave Energy Desalination Technologies	page 19
Sistema.bio From Waste to Energy: Standardizing the Work-Stream of Biodigester Solutions	page 20
US Environmental Protection Agency Cold Weather Anaerobic Digesters: Challenges and Opportunities	page 21
WASE Ltd. Aiding Design of a Wastewater Treatment Biocentre for Commercial Validation	page 22

7 AFFORDABLE AND CLEAN ENERGY



Amped Innovation Development of a High Autonomy Solar Fridge	page 23
M-KOPA Battery Management Systems and Analytics for e-Mobility	page 24
SolarBuddy Advancing Low-Cost Solar Cooking Technology	page 25

9 INDUSTRY, INNOVATION, AND INFRASTRUCTURE



Autodesk Foundation Advancing the Use of Design and Manufacturing Technology in Startups and Nonprofits	page 26
Moving Health Modeling Existing Ambulance Tricycle Prototype and Proposing Strategies for Operations of Health Transport Services in Sissala East District, Ghana	page 27

11 SUSTAINABLE CITIES AND COMMUNITIES



Bridges to Prosperity Impact of Rural Trailbridges on Adjacent Infrastructure in East Africa	page 28
BuildChange Automating Structural Retrofits for Low-Income Households in Bogota, Colombia	page 29
BuildX Studio Quantifying Embodied Energy: Considering Carbon Footprints in Schematic Design for Modular Housing Projects	page 30

EarthEnable Dignified Rural Home Design in Rwanda Using Adobe Block	page 31
Habitat for Humanity International Circular Economies and Affordable Housing in Kenya	page 32
Habitat for Humanity International Circular Economies and Affordable Housing in Mexico	page 33
Penn State University Engineering Design Recommendations for Resilient Housing: A Case Study of Dar es Salaam in East Africa	page 34
United Nations High Commissioner for Refugees (UNHCR) Development of Templates to Support an Integrated Settlement Planning Framework in the Context of Refugees, Humanitarian, and Conflict Affected Areas	page 35

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



BamCore From CAD to CAM: Streamlining Workflows for Custom Prefabricated Construction	page 36
Industrial Sewing and Innovation Center (ISAIC) Virtual Training and Assistance in the Apparel Industry	page 37
TAM Associati From Product to Project: Scaling the Gap from BIM to Full Scale 3D Printing	page 38

13 CLIMATE ACTION



twelve CAD Modelling and Version Management of Electrolyzer Test Systems	page 39
--	---------

14 LIFE BELOW WATER



SECORE International Developing 3D-Printed Structures for Novel Coral Restoration Method	page 40
--	---------

15 LIFE ON LAND



WeRobotics Aerial Release of Mangrove Seeds to Support Coastal Ecosystem Restoration	page 41
--	---------

17 PARTNERSHIPS FOR THE GOALS



Autodesk Foundation Advancing Communities of Practice through a Technology Leadership Program	page 42
---	---------

IMPACT PROJECTS E4C 2021

11 SUSTAINABLE CITIES
AND COMMUNITIES



15 LIFE
ON LAND



17 PARTNERSHIPS
FOR THE GOALS



14 LIFE
BELOW WATER



6 CLEAN WATER
AND SANITATION



8 DECENT WORK AND
ECONOMIC GROWTH



13 CLIMATE
ACTION



7 AFFORDABLE AND
CLEAN ENERGY



9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



3 GOOD HEALTH
AND WELL-BEING



2 ZERO
HUNGER



4 QUALITY
EDUCATION



Kheyti

Improving DIYability of Small Scale Greenhouses

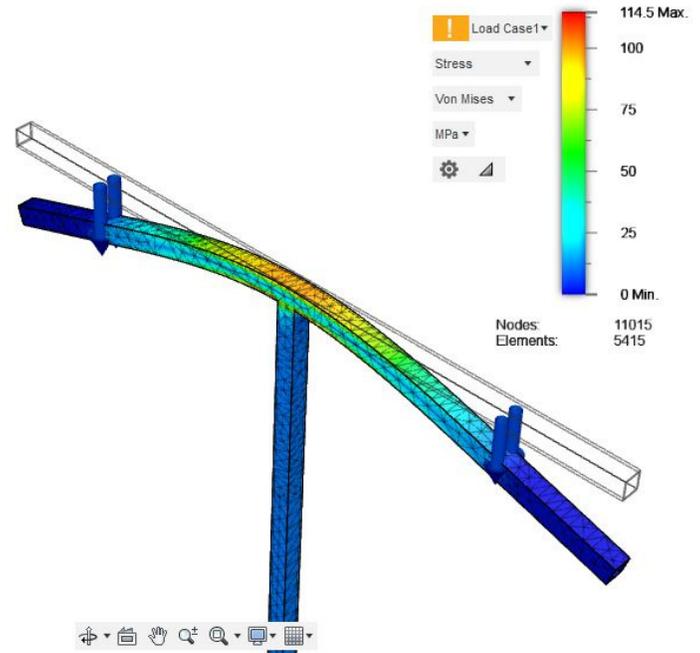
In 2021, Kheyti's R&D Team decided to work on developing a new version of the "Greenhouse in a Box", which is an affordable \$500 "Greenhouse Lite" for bottom-of-the-pyramid farmers. The goals were to simplify installation and reduce the cost of the greenhouse.

With the world's population at 7.9 billion in July 2021, our food scenario is changing fast, particularly with climate change making production all the more difficult for today's farmers. Goal 2 of the United Nations (UN) Sustainable Development Goals (SDGs) seeks sustainable solutions to end hunger in all forms by 2030 and to achieve food security. Kheyti has taken up this challenge since 2015, developing a greenhouse in a box that provides year-round income for farmers in India.

By adopting a human-centred approach and conducting interviews with farmers, potential pain points during farmer's installation in the current model were identified and expert installation, accounting for 20% of the greenhouse cost, were estimated. Collaborative design tools like Autodesk Fusion 360 allowed Autodesk consultants and partners (KETIV Technologies), E4C fellows, and Kheyti designers to work on one platform, brainstorming, suggesting, making and testing design iterations.

The new ideas were identified during the brainstorming sessions in the collaboration. These new ideas were then practically tested in the field by the Kheyti team. The field tests helped to identify issues, iterate and improve the ideas for simplicity of installation and cost reduction.

The collaboration resulted in a 10% cost reduction and 50% reduction in installation time. Achieving the set goal is not just good news to Kheyti but also to the farmers. Now, they will be able to produce more food, repay their loans faster and feed the growing population of the world - helping to achieve the UN SDGs.



Fusion 360 validation results for proposed trellising system

Fellow:
Obiora Odugu, Nigeria

Program Coordinator:
Harsh Vyas, India

Partner collaborators:
Ash Seth, Senior Design Engineer, USA
Ayush Jain, Kheyti Design Fellow, India
Ayush Sharma, Kheyti Cofounder, India

This work was sponsored by:
Autodesk Foundation

This work is in collaboration with: **Kheyti**
<https://www.kheyti.com/>



2 ZERO HUNGER



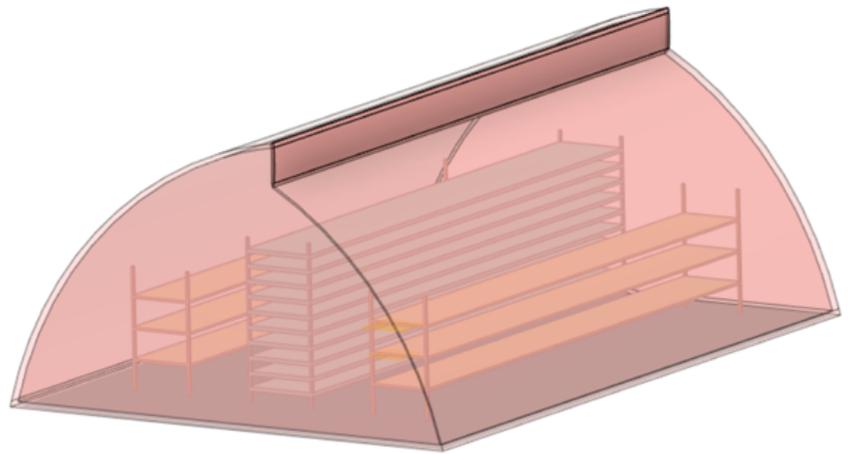
Sanergy

Greenhouse Larvae Bed Cooling

Sanergy converts organic waste into useful agricultural outputs such as insect protein, organic fertilizer and briquettes. The goal for this project was to design an air handling system to provide optimum levels of fresh air in the controlled environment to larvae to maximize the yield of the final product.

The process uses larvae to convert organic wastes to quality agricultural output requiring larvae to be kept under a controlled environment in a greenhouse. In order to maximize the larvae production yields, ideal growing conditions are needed such as airflow and temperature. The team worked on providing insights into room air handling system configurations to manage airflow around the shelving. Airflow control is critical to managing ammonia and CO₂. The task was further divided into Micro and Macro Climate in which the Micro Climate needed to be designed to provide fresh air to beds and the Macro Climate to achieve the required number of air changes per hour inside the greenhouse. Air changes help to control the ammonia levels in the greenhouse.

The team brainstormed ideas for different air handling systems considering the complexity for installation and operation, reliability, CAPEX, and OPEX. For the Micro Climate design, the team explored empirical data from published research in this field. For the Macro Climate design, the team used Autodesk workflows such as Fusion 360, Autodesk Inventor to build the CAD model of the shelving and greenhouse. Autodesk CFD was used to run simulations replicating the controlled environmental conditions of the greenhouse virtually. A combination of design, prototype, modeling, and iteration was used to propose the best orientation of the exhaust fan for an improved process.



Greenhouse prototype

Fellow:

Mahmoud El-Sadek, Egypt

Program Coordinator:

Harsh Vyas, India

Partner collaborators:

Walid Kamal, Director

Matthieu Desvignes, Construction Manager

Nathan Kolibaba, Process Engineer

Patrick Nubuhoro, Process Engineer

Maurice Bawarva, Mechanical Engineer

Tom Hagerty, Make Product Specialist, Autodesk Inc.

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Sanergy

<https://www.sanergy.com>

SANERGY

2 ZERO HUNGER



S4S Technologies

Design of an Automatic Tomato Cutting Machine

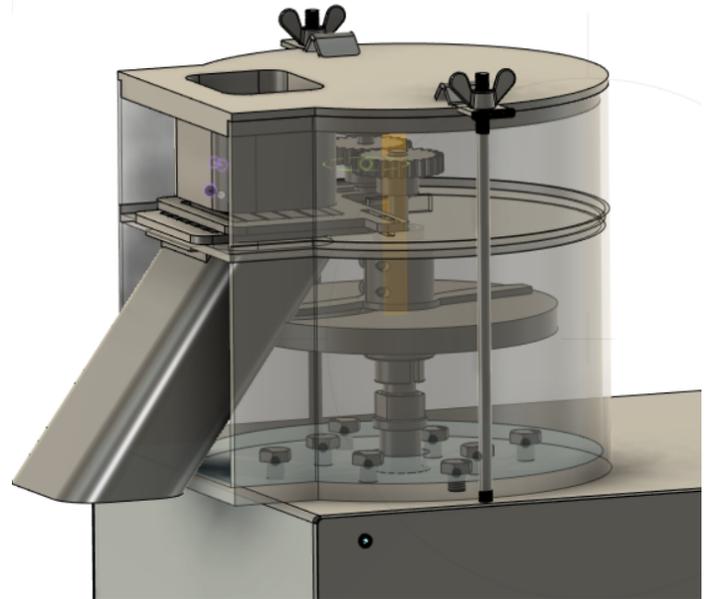
Farm-based food processing via dehydration is a significant way to save post-harvest losses and help farmers earn extra income by reducing the waste and selling value-added products. A combo cutter is a machine that is used for preprocessing before it is dehydrated.

This automatic machine cuts large quantities of vegetables and fruits into defined size cubes, so that it can be efficiently dehydrated in solar dehydration machines. Commodities such as ginger, garlic, onion, and turmeric are comparatively easy to slice, whereas tomatoes are more challenging since they are soft and squeezable. The goal of this project was to solve the issue of mass tomato cutting by designing an automatic machine that can efficiently dice tomatoes into 14x14 mm size cubes.

To address this problem, prior art was identified via academic and market research. Through this search of the literature, parameters such as blade angle, applied shear cutting force, and non-skid fixture were identified as playing a critical role for the efficient cutting of tomatoes.

Additionally, through market research we discovered that automatic machines have been designed for industry and for assembly line infrastructure, but the cost of the machines was 10 to 100 times higher than what we were trying to build for rural India. On the other hand, manual machines available in the market were cheaper and performed efficiently but had limitations for bulk processing.

Combining findings from the academic and market research, the team collaborated using Slack, Asana and Autodesk Fusion 360 to design a machine that met the requirements. These tools helped to create the 3D assembly files of the machine, manufacturing 3D CAD Models, CAD drawings, detailed Bill Of Material (BOM), and assembly instructions making work easier for creating the first prototype.



3D CAD model of tomato cutting machine

Fellow:
Tanvir Khorajiya, India

Program Coordinator:
Harsh Vyas, India

Partner collaborators:
Ashwin Pawade, Co-Founder and Lead, S4S Technologies, India
Mandar Palande, Manager, S4S Technologies, India

This work was sponsored by:
Autodesk Foundation

This work is in collaboration with:
Science for Society (S4S) Technologies Pvt. Ltd.



2 ZERO HUNGER



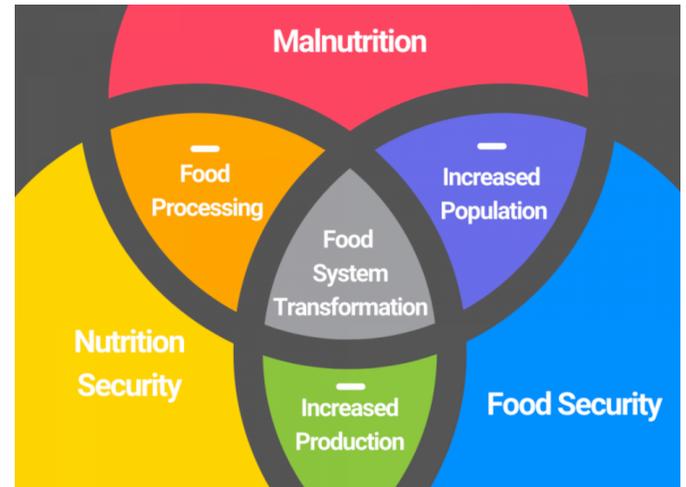
University of Missouri

Advancing Towards SDG 2 in Nigeria: Food and Nutrition Security in Borno State

Achieving Sustainable Development Goal (SDG) 2: Zero Hunger requires a multifaceted approach, including assessments and solutions for malnutrition, food security and nutrition security. Africa remains one of the most affected regions by malnutrition and, as a direct result, food and nutrition security. Most of the continent, 22 of the 34 countries, are affected by malnutrition, seven of these alone are in West Africa.

Located in West Africa, Nigeria is the most populous and largest economy in Africa. However, according to the Global Nutrition Report, Nigeria has the second largest population of “stunted” and “wasted” children in the world; 13.9 million and 3.4 million respectively. According to the 2021 SDGs Report, Nigeria ranks 160 out of the 165 countries regarding their progress towards achieving the SDGs. Specifically, the nation faces significant challenges with respect to SDG 2, with minimal progress made in reducing the prevalence of stunting and wasting among children under 5 years.

In partnership with the Food Engineering and Sustainable Technologies (FEAST) Lab at the University of Missouri, the aim of this study was to (1) identify the challenges organizations face in addressing food and nutrition security issues in the region and (2) highlight existing approaches to addressing these challenges and recommend alternative approaches based on exchanges with field experts. We conducted seven interviews with experts working in agricultural, health, and environmental sectors in the region. Using a qualitative analysis approach, we synthesized both primary and secondary data to develop trends and recommendations. This report provides insights into the challenges and difficulties organizations and institutions face in addressing food and nutrition security in the region. Further, the report provides information on existing policies and strategies implemented by organizations to reduce the malnutrition effects in the region. Our findings also highlight the ways in which the insurgency by Boko Haram has impacted efforts in the region and proposes appropriate recommendations and solutions.



Key axes and approach to researching food and nutrition security

Fellows:

Randolf Hackman, Ghana

Joseph Bainamndi, Cameroon

Expert Fellow:

Khaoula Trigui, Tunisia

Partner collaborators:

Dr. Kiruba Krishnaswamy, Assistant Professor, University of Missouri

View the full report:

<https://www.engineeringforchange.org/research/advancing-towards-sdg-2-nigeria-food-nutrition-security-borno-state>

This work is in collaboration with:

Food Engineering and Sustainable Technologies (FEAST) Lab,
University of Missouri
<http://feastlab.org/>



University of Missouri



Build Health International

Masterplan Proposal for Hospital Wesleyan de La Gonâve, Haiti

This collaboration aimed to support Build Health International (BHI)'s efforts in documenting the existing mechanical and electrical systems for the Hospital Wesleyan de La Gonâve in Haiti. Additionally, the fellowship sought to develop a standard internal procedure that the organization can use to enable information gathering and synthesis for assessing such systems in hospitals and campuses located in low and middle-income settings.

In contexts of limited resources, it is often difficult for healthcare settings to adhere to international standards. The Development of analysis frameworks and evaluation metrics therefore are often needed in these spaces to inform and guide effective assessments of critical electrical, Water, Sanitation and Hygiene (WASH), solid waste management, plumbing, ventilation, and fire safety infrastructure.

The existing hospital under analysis serves the approximately 130,000 inhabitants of La Gonâve Island. Several of its critical infrastructure systems are in a poor state and some essential medical services are not offered, forcing people to travel long distances by boat so as to access medical services on the main island. The work carried out for this project aims to improve the access to quality, affordable and sustainable healthcare services by applying a framework that guides long and short-term strategy while identifying prioritized capital projects.

This collaboration began by conducting an analysis of data gathering and site assessment strategies for existing healthcare facilities; with the goal of developing a data collection framework for the Wesleyan Hospital that enables remote observation through the use of High-Quality 3D imagery. Interview protocols to gather insights from key stakeholders were also developed in order to fill in the gaps of knowledge encountered through the remote observation systems. Upon initializing the established protocols, the states and compliance of the hospital's mechanical, electrical, and plumbing systems were documented, assessed, reported on, and integrated into architectural building plans to accurately reflect the facilities present. The fellowship concluded with the drafting of a critical systems assessment report that includes phased recommendations for the improvement of the different engineering systems and the creation of a blank field assessment template that BHI can use for future projects.



Aerial drone image of the Hospital Wesleyan de La Gonave complex, Haiti (Source: BHI)

Fellow:

Kevin Ndeti, Kenya

Program Coordinator:

Carolina Rojas Echeverri, Panama

Partner collaborators:

Gerard Georges, Director of Architecture; **Allison Denisky**, Senior Architectural Designer; **Jaresiah Desrosiers**, Facilities Manager; **Eric Buckley**, Senior Structural Engineer

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Build Health International

www.buildhealthinternational.org



3 GOOD HEALTH AND WELL-BEING



Chemonics

Climate Monitoring for Ambient Health Commodities Supply Chains

Although an enormous quantity of products moves through global health supply chains on a daily basis, the storage and transportation environment for ambient health products – from international transport through the last mile – is not well understood. Maintaining the proper environment for health commodities is vital to ensuring their quality.

It is critical for all health supply chain players and manufacturers to ensure that pharmaceutical products are transported, stored, and delivered to consumers in a stable state. Prolonged climate excursions have adverse effects on the quality and efficacy of medicines making them less effective and unsafe.

Starting in 2017, Chemonics, supported by the USAID Global Health Supply Chain- Procurement and Supply Management (GHSC-PSM) project, The Bill and Melinda Gates Foundation and The Global Fund, has collected temperature and humidity data from sensors in international shipments, in-country trucks, among other supply chain locations (warehouses, hospitals, etc.) for ambient pharmaceutical commodities. In 2021, Chemonics partnered with Engineering for Change to standardize, extract, and analyze the collected data.

The collaboration between Engineering for Change and Chemonics is planned to extend into 2022. Findings and recommendations will be published in a white paper.



*Warehouse employee moving medical shipments
(Source: Chemonics)*

Fellows:

Paulo Vela, Peru

Julius Mugaga, Uganda

Expert Fellow:

Erin Peiffer, USA

Partner collaborators:

Chemonics' Development Research and Chemonics' Supply Chain Practice Team

This work is in collaboration with:

Chemonics



3 GOOD HEALTH AND WELL-BEING



VIA Global Health

Improving Medical Device Procurement in Africa: A Decision Support Tool for Considering Total Cost of Ownership

Low and middle-income countries (LMICs) rarely manufacture their own medical devices but heavily rely on importing up to 95% of these products. LMICs rarely have the expertise to advise on procurement of medical devices suited for their resource-constrained settings coupled with the fact that medical device manufacturers are located in and accustomed to high-income countries.

For medical products, the total cost of ownership (TCO) considers the cost to purchase, install, operate, maintain, and dispose of medical equipment for its lifetime. It is estimated that most procurement decisions for medical devices are based on the initial purchase cost, which is only 20% of the total cost of owning medical equipment for its lifetime. The other 80% of the costs are mostly hidden. In healthcare, the TCO concept is rarely used during decision-making, and the process is not standardized. Therefore, our objective is to develop a simple TCO tool to guide the purchasing decisions of medical devices in West Africa and potentially other regions.

Through desk research and interviews with key stakeholders involved in medical device procurement in West Africa, we mapped the process of product purchasing in the region to identify the considerations and challenges, particularly concerning TCO. Ultimately, we aimed to develop a decision-making tool that addresses their challenges with incorporating TCO.

Our findings suggest that the challenges with medical device procurement related to a lower consideration for the TCO include budget constraints, lack of established guidelines and standards, and a low level of expertise in this regard. We developed a preliminary decision support tool for TCO considerations for medical device purchasing in Africa through expert insights and desk research. Although this tool is still in development and requires further testing and validation to be fully operational, it is intended to address gaps in previous tools and help plan medical device procurement in West Africa, with potential application across the African continent. This tool is designed to be simple, widely applicable across different geographies and device categories rather than provide actual costs or quantitative information, which are so variable, to encourage prospective buyers to consider factors other than upfront cost when making a purchasing decision.



*Decision making for medical devices
in Africa*

Fellow:
Miracle Ndego, Ghana

Expert Fellow:
Khaoula Trigui, Tunisia

Partner collaborators:
Brinnon Mandel, Vice President,
Strategic Partnership
Noah Perin, CEO & Co-founder

View the full report: <https://www.engineeringforchange.org/research/improving-medical-device-procurement-africa-decision-support-tool-considering-total-cost-ownership>

This work is in collaboration with:
VIA Global Health
www.viaglobalhealth.com



3 GOOD HEALTH
AND WELL-BEING



Adaptiv

Prototype School Design for Remote and Accessible Schools in Haiti

In collaboration with Adaptive, Fellows developed a prototype design for remote and accessible schools in Haiti. This includes the inputs of research and the lessons learnt from previous projects, to develop architectural, structural and WASH concept designs.

Haiti is the poorest country in the western hemisphere and many schools are challenged with poor quality infrastructure, significant overcrowding, inadequate natural light and ventilation, and a lack of access to water and sanitation infrastructure. All of which are intensified by Haiti's exposure to natural disasters, such as earthquakes and hurricanes. This prototype school has been designed to address these challenges and provide quality educational infrastructure across Haiti, starting with the implementation of the prototype across the 40 schools that Summits Education operates.

The development of the prototype design involved assessing previous projects carried out by Adaptiv and other organisations, to address the challenges faced and develop design solutions. Secondly, in-depth research was carried out into architectural and structural design, WASH and energy solutions. This enabled an assessment matrix to be developed to qualitatively assess these materials and systems. This matrix enabled key considerations and constraints to be analysed, while factoring in stakeholder priorities to establish the optimum prototype design. This led to the development of design standards for the prototype school, of both remote and accessible sites across Haiti.

This prototype will act as a basis of design for remote and accessible schools across Summits Educations network, to provide long lasting infrastructure which addresses the critical challenges faced in Haitian schools, allowing for quality education and equity to be achieved. The prototype will enable Summits to efficiently operate and maintain all of their schools, allowing them to focus on their core mission of investing in and developing teachers, as well as promoting an environment where students are healthy, safe, actively engaged and supported.



St. Marcs School in Haiti

Fellow:
Lowri Swygart, UK

Program Coordinator:
Elisabeth van Overbeeke, Canada

Partner collaborators:
Rob Freni, Killion Mokwete, Abby Gordan, Herve Sabin, Cassandre Regnier, and Carolyn Mellin

This work was sponsored by:
Autodesk Foundation

This work is in collaboration with:
Adaptiv
www.adaptiv.org



4 QUALITY EDUCATION



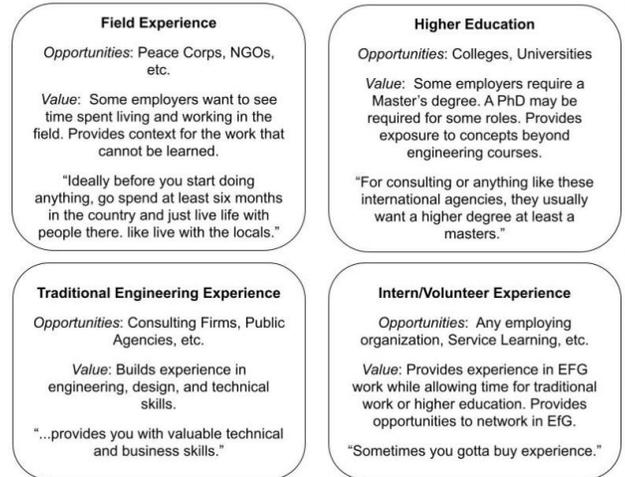
Colorado School of Mines

Mapping 'Engineering for Good' Career Pathways: Examples from North America

Through a research collaboration between Engineering for Change and the Colorado School of Mines, we have developed a career map for engineers trained in North America and who desire to work in Engineering for Good (EfG). EfG is defined as “the practice of prioritizing doing good over more traditional engineering urgencies such as cost, technological efficiency, and innovation” and includes work in international and domestic community development, disaster response, and poverty alleviation. As more and more academic programs related to EfG are being offered in North America, early-career engineers and engineering students are eager to start their careers in EfG, but often find few resources to guide their job search. There is a growing demand for engineers committed to sustainable humanitarian practices, with a growing population of well-trained graduates prepared to take on their roles. To help these two groups come together, a well-developed map can be a tool that allows students to align their professional careers with their aspirations.

Through desk research and interviews with 8 EfG engineers, we have developed the three-stage EfG Career Map that shows how engineers can progress from earning a Bachelor's degree (Stage 1) to finding a career in EfG (Stage 3). In Stage 2, we have identified 4 common early-career experiences: field experience, higher education, traditional engineering experience, and intern/volunteer experience, as well as common skills to develop in one's early-career. In Stage 3, the map shows EfG example roles and organization types to provide reference in this amorphous, evolving area of engineering.

Concepts like considering what it means to be an engineer in terms of the 'whole self' as well as planning one's career path under the principle of 'structured serendipity' emerged from our collective data set. These highlighted ideas speak to the value of personal, emotional, and creative skills for finding a fulfilling career in EfG. Expanded on below are ways a student or professional can pragmatically apply these themes to developing their career for doing good. We recommend that additional research be completed to better understand the characteristics of established EfG career roles and the types of organizations involved in EfG, as well as how different types of engineering majors may affect the future EfG roles available to an engineer.



Common early-career experiences in EfG map

Fellows:
Rachel Geiger, USA
Scott West, USA

This work is in collaboration with:
Colorado School of Mines

Expert Fellow:
Erin Peiffer, USA



Partner collaborators:
Dr. Marie Stettler Kleine, Teaching Assistant Professor
Dr. Juan Lucena, Professor

View the full report: <https://www.engineeringforchange.org/research/mapping-engineering-good-career-pathways-examples-north-america>

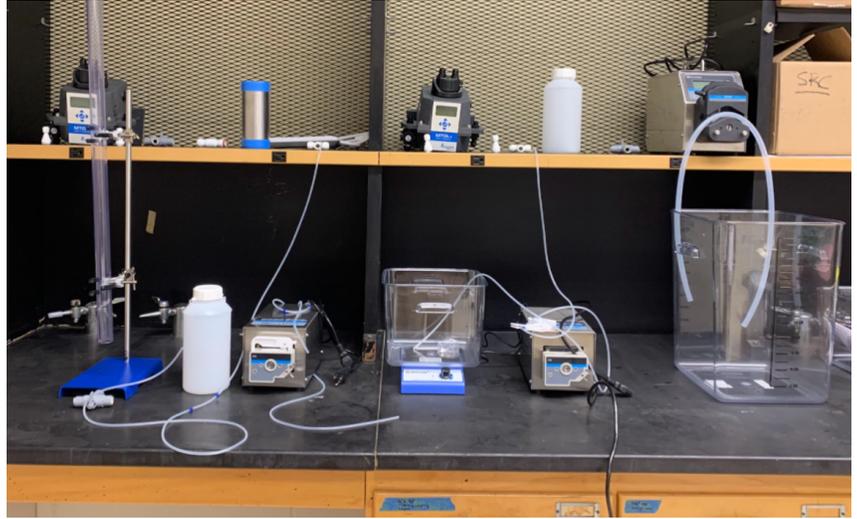
4 QUALITY EDUCATION



The Ohio State University

Designing University Lab Space: Recommendations for Engineering for Global Development Programs

The field of Engineering for Global Development (EGD) has been evolving and growing in U.S.-based universities. Many EGD-related programs provide physical lab spaces that allow for team-based, multidisciplinary, experiential learning opportunities that engage students at multiple points in their academic careers. These EGD-related lab spaces often cater to a variety of technical, environmental, and social research and projects. The purpose of this research collaboration was to categorize and provide recommendations for new and developing EGD-related lab spaces within university settings. To understand the current landscape, Fellows conducted desk research of 23 universities with EGD-related programs. To supplement, Fellows conducted semi-structured interviews with individuals representing 11 universities.



Lab bench at the new Ohio State Humanitarian Innovation Lab

Across the universities investigated, labs have a wide variety of organization and funding of these labs (e.g., state, grants, industry partners). Students' involvement in the labs varies, including how students are recruited and what training, tools, and resources are available. Programs face challenges related to university structure, project sourcing, and resource constraints. Meanwhile, success factors include industry support, passionate faculty, and clear communication of the space's value-addition to a department or university. Based on these findings, Fellows identified recommendations for creating and sustaining EGD-related lab spaces, including ways to get students involved in sustainable development innovation, and how to address and alleviate challenges. Rather than providing a strict set of guidelines for future programs to follow, this report is meant to serve as a record of lessons-learned from existing EGD-related programs.

Fellow:

Emily Crawley, USA

Matt Parsons, USA

This work is in collaboration with:

The Ohio State University



THE OHIO STATE UNIVERSITY

Expert Fellow:

Patrick Sours, USA

Partner collaborators:

Dr. Michael Hagenberger,

Associate Dean, OSU

View the full report: <https://www.engineeringforchange.org/research/designing-university-lab-space-recommendations-engineering-global-development-programs>

4 QUALITY
EDUCATION



Kickstart International

Development of an Analytics Platform for Real Time Monitoring of Water Pump Usage

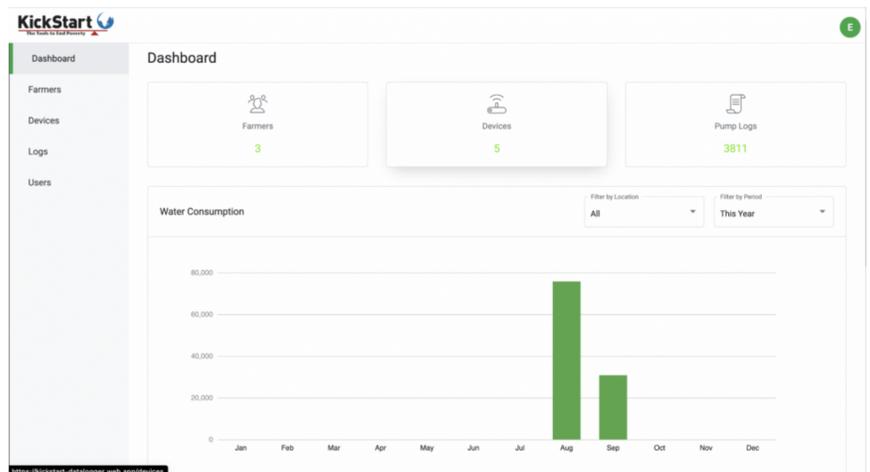
KickStart International commissioned the data logger project to enable the team to monitor, observe, and get insights on pump functionality and utilization. The logs retrieved from the pumps provide valuable insight on farmer behavior as well as a window for the technical team to remotely observe and diagnose pump issues.

The data loggers leveraged SMS (Short Message Service) messaging to send data to KickStart International's Nairobi Office every five minutes. Using a message synchronization software, the team would then transfer messages from the phone to an excel sheet where the business intelligence team could graph out the data for insights on usage and pump diagnostics. A considerable challenge that emerged in this sequence was that the process was reliant upon bulk processing (at the end of the day or week) from phone to excel sheet, preventing the team from gathering real-time analytics to respond to issues quickly.

Over the course of the fellowship, an IoT Data Logger was developed to send data, in real-time, to a custom analytics service for immediate processing and visualization. The pumping devices were first configured to send data to ThingSpeak, an IoT analytics platform service that allows the user to aggregate, visualize, and analyze live data streams in the cloud.

After this proof of concept was deemed successful, the team moved on to build out a custom analytics platform suited to KickStart's specific requirements that would log the data, process it, and provide application programming interfaces (APIs) for a front-end web application to consume and visualize it for the KickStart team.

With this new approach the KickStart team now has access to real-time data on whether the pumps are functional, how much water has been pumped, and the pump's real-time location. Furthermore, this has opened up the opportunity to tie the data to farm productivity which, alongside other parameters such as soil profile, can be used to boost the farm's productivity to the benefit of the farmer.



The dashboard for the analytics platform

Fellow:

Emmanuel Kinyanjui, Kenya

Program Coordinator:

Harsh Vyas, India

Partner collaborator:

James Mwaniki, Consultant

Firmware Engineer

Alan Sybby, Director of Product Intelligence and Development

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Kickstart International

<https://kickstart-datalogger.web.app/>



6 CLEAN WATER AND SANITATION



Médecins Sans Frontières

A standard, Adaptable Catalogue of Water Tower Designs and Construction Typologies

As an international humanitarian response organization, Médecins Sans Frontières (MSF) is often confronted with the challenge of providing clean and reliable water supply to support its emergency, post-emergency and regular medical programs. The scale of these efforts often require the storing and distribution of water over substantial areas, making elevated water storage towers a vital piece of infrastructure. As site conditions vary and the supply/demand constraints are unique to each mission, this project sought to produce a catalogue of structurally-sound water towers that can be quickly consulted to provide appropriate, site-specific construction guidance.

In response to the numerous variables that shape the design of any water tower – from supply/demand, to soil bearing capacities, to wind loads and local seismic activity – a Design Risk Matrix was developed which yielded 36 different design typologies across four delineated risk categories. Over the course of the Fellowship nine of these tower designs were produced along with their respective technical drawings and material quantities, forming the foundation of the design catalogue.

Running in tangent to the development of the designs, strategies for knowledge transfer and concerns for responsible use of the catalogue tool were also considered. Autodesk's Inventor iLogic has proven particularly promising in this regard. Using field-specific design constraints entered by MSF staff, iLogic can automate navigation through the design typologies and customize the sizes of structural members and connection details, culminating in construction drawings and material spreadsheets for a site-specific design. Further investigation and development of these systems through Autodesk's Forge platform will facilitate consultation of the catalogue through a standard internet browser, making it ideal for field-based implementation where a connection is available.

Total number of Models: 36	Model 4: Capacity = 5 m ³ Height of Tower = 6 m	Model 5: Capacity = 10 m ³ Height of Tower = 6 m	Model 6: Capacity = 20 m ³ Height of Tower = 6 m
Low Risk: Peak Gust Wind Speed = 15 m/s Peak Ground Acceleration = 0.01 m/s ² Minimum Safe Soil Bearing Capacity = 2000 kN/m			
Low-Medium Risk: Peak Gust Wind Speed = 25 m/s Peak Ground Acceleration = 0.9 m/s ² Minimum Safe Soil Bearing Capacity = 600 kN/m			
Medium-High Risk: Peak Gust Wind Speed = 35 m/s Peak Ground Acceleration = 1.8 m/s ² Minimum Safe Soil Bearing Capacity = 300 kN			
High Risk: Peak Gust Wind Speed = 45 m/s Peak Ground Acceleration = 3.3 m/s ² Minimum Safe Soil Bearing Capacity = 100 kN/m			



A segment of the Design Risk Matrix for assessing 36 different design typologies across four risk categories

Fellow:

Sam Butterworth, UK

Program Coordinator:

Charles Newman, USA

Partner collaborator:

Paul Cabrera, MSF OCBA

Construction & Shelter Advisor

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Médecins Sans Frontières

www.msf.org/



6 CLEAN WATER AND SANITATION



National Renewable Energy Laboratory

Accelerating the Advancement of Wave Energy Desalination Technologies

As the global population increases, meeting the basic needs of all becomes more challenging. One of the most basic needs for humans is access to clean water. Many people across the globe either live in water-stressed areas or lack access to potable water which is suitable for human consumption. In areas with limited access to clean water, desalination systems are being proposed as a solution. However, the desalination process is energy-intensive and the use of non-renewable energy resources to power such systems presents negative impacts on the natural environment. Therefore, the use of renewable energy sources such as wave, solar, and wind are now being deployed to power desalination technologies to generate clean water in a more sustainable manner.

This report provides a background on the wave energy and desalination sectors, specifically, and how these technologies can address the global water issue. It also highlights the present status of both fields, including the different types of systems available and the potential to integrate both together. Challenges and opportunities within the wave energy sector are also highlighted with an aim to capitalize on the opportunities while addressing the challenges.

The Waves to Water Prize presents an opportunity to promote the development of desalination technologies powered by a low carbon energy source. The goal of this prize is to accelerate the development of wave-powered desalination technologies for remote island communities and disaster relief scenarios. The \$3.3 million USD prize is awarded throughout the competition to teams that advance to the next prize stage. The winning team will have had to successfully create a desalination system powered by renewable wave energy which is small enough to fit into a palletized container, is modular to allow for scalability, and is also cost-competitive. As a partner supporting the prize, Engineering for Change (E4C) has provided engineering support and market analyses for both the development and implementation of the competing technologies. Driving development and innovation in this emerging sector will require investment across a number of dimensions including, but not limited to:

- Increased funding opportunities for individuals and groups working on these technologies
- Collaboration with academia, industry, nonprofits, and government entities for a holistic approach in developing these technologies for widespread adoption
- Collaboration with diverse organizations representing end-user needs for wave-powered desalination design
- A robust procurement pathway for products with growth of the innovation ecosystem attracting diverse entrepreneurs via platforms such as prizes (ex. Waves to Water Prize) to facilitate funding and networking



Fellows:

Sahar Shamsi, Canada

Buddila Wijeyesekera, Sri Lanka

Expert Fellow:

Erin Peiffer, USA

View the full report: <https://www.engineeringforchange.org/research/supporting-development-wave-energy-desalination-technologies-waves-water-engineering-change-partnership>

This work is in

collaboration with:

National Renewable Energy Laboratory



6 CLEAN WATER AND SANITATION



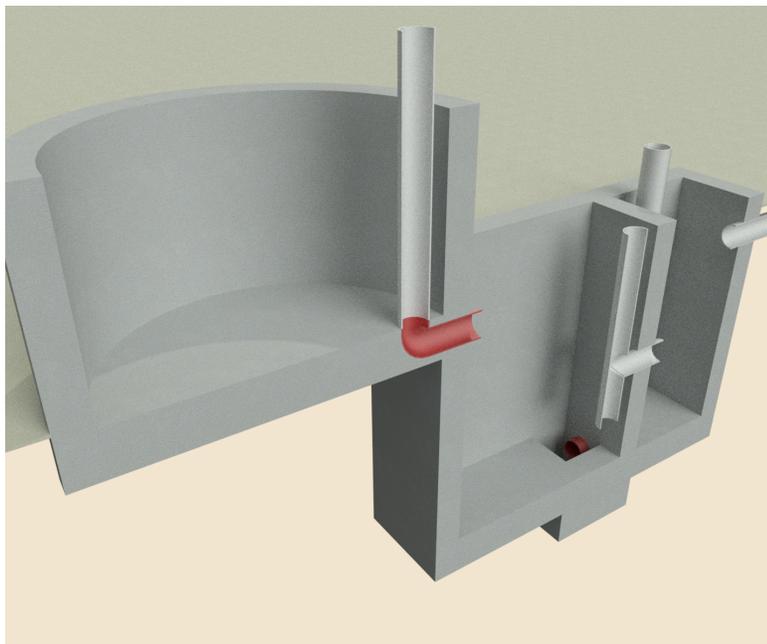
Sistema.bio

From Waste to Energy: Standardizing the Work-Stream of Biodigester Solutions

With the aim of increasing the impact of biodigesters on farmers' livelihoods and productivity, this project focused on improving the work-stream of Sistema.bio's solutions by standardizing its designs. Farming systems are the backbone of energy and food security. Mismanagement of their waste and byproducts, however, jeopardize their long-term productivity and compromise the environmental quality. To contribute to a more sustainable agriculture, Sistema.bio provides biodigester solutions that transform organic waste from farms into environmentally sound biogas and biofertilizer.

This project diagnosed the current workflow of the implementation of large productive biogas installations. Sistema.bio has regional teams in Kenya, India, Mexico and Colombia, covering a wide spectrum of large productive farms' requirements and thus has to cater to an equally broad range of needs. Each regional team tailors their proposals to their respective contexts in order to make sure that the proposed technical solution corresponds to the farm activities. However, these divergent lines of action lead to unstandardized designs and drawings, which may ultimately affect the efficiency and accuracy.

To standardize these processes, four strategies were considered while using Autodesk® AutoCAD to design a solution. First, a repository of standard designs was created; it consists of a number of drawings of Sistema.bio's equipment including civil structures. Second, a master AutoCAD farm layout template was designed, which can be quickly adapted to each farm's own and unique site conditions that will integrate standard and/or tailor made equipment. Third, both standard designs and master templates were made through a layer-based approach; this enables the quick customization of visual styles without the need to redraw. Last but not least, the cloud integration across regional teams is accomplished by using the web-based Autodesk® Viewer. The standardization of Sistema.bio's solutions for productive farms will have a two-fold impact. On the one hand, it will reduce the time for proposals while increasing their quality and efficiency. On the other hand, it will improve the communication between company and customers, thereby fostering the effective adoption of biodigesters for a more sustainable future.



Rendering of cross-sectioned biodigester feeding tank

Fellow:

Juan Carlo Intriago Zambrano, Ecuador

Program Coordinator:

Carolina Rojas Echeverri, Panama

Partner collaborator:

Maxence Affre, Global Technical Director

Oscar Ominde, Proposal Manager

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Sistema.bio <https://sistema.bio/>



6 CLEAN WATER AND SANITATION



US Environmental Protection Agency

Cold Weather Anaerobic Digesters: Challenges and Opportunities

In Alaska, over 3,000 households currently use unpiped sanitation systems to collect human waste and nearly 80% of rural households rely on diesel to meet their energy needs. A consistent concern and priority that is expressed to the U.S. Environmental Protection Agency (EPA) from Alaska Native Villages is the need for basic sanitation and treatment options for raw sewage. The EPA is interested in exploring the multi-benefit use and feasibility of anaerobic digestion (AD) for both sanitation and energy improvements for off-grid Alaskan communities. AD is a proven and effective biological treatment process that relies on microorganisms to break down organic matter (OM), effectively reducing pathogens and producing biogas as a byproduct and potential energy source.

This research report summarizes findings from a landscape analysis of AD with a focus on identifying 1) where AD has been used in cold weather or high elevation locations; 2) challenges associated with implementing AD systems; and 3) opportunities for funding and implementing cold weather AD design in Alaskan communities. The landscape analysis involved conducting a literature review, interviewing experts in the field, and reviewing current technologies to identify challenges, gaps, and opportunities for implementing anaerobic digesters in rural Alaskan communities. After data cleaning, 32 out of the 50 experiments reported successfully testing out AD in 20°C or colder operating temperatures. The most significant barriers to implementing AD systems include freezing temperatures, having trained operators and consistent monitoring, affordability, and access.

Overall, the initial analysis indicates that AD systems can operate at low temperatures, effectively achieve pathogen reduction, and generate biogas (although limited). Yet, there are persistent gaps in the implementation of field-scale cold weather AD systems, especially in the Arctic and sub-Arctic regions. Key recommendations include:

- Conducting field-scale testing of digesters to account for various design and operational strategies.
- Implementing centralized systems for easier operation and maintenance.
- Incorporating external heating, with an emphasis on both passive and active methods.
- Investigating improved and reliable collection and conveyance strategies.
- Involving and integrating community priorities, values, and feedback throughout the design and implementation processes.



*A tubular digester implemented in Laguna Colorada, Peru
(Source: Dr. Jaime Martí-Herrero)*

Fellow:
Jessica Egan, USA

This work is in collaboration with:
United States Environmental Protection Agency

Expert Fellow:
Erin Peiffer, USA

Partner collaborators:
Margaret McCauley, Environmental Engineer, U.S. EPA
Embrey Bronstad, Environmental Engineer, WSU

To view the full report:

<https://www.engineeringforchange.org/research/cold-weather-anaerobic-digesters-challenges-opportunities/>

6 CLEAN WATER
AND SANITATION



WASE Ltd.

Aiding Design of a Wastewater Treatment Biocentre for Commercial Validation

It is estimated that 1.6 billions tonnes of food, worth about \$1.2 trillion, is wasted globally each year. Much of this waste goes to landfill, decomposing and releasing greenhouse gases. Additionally, the natural environment and water systems are being destroyed by approximately 200,000 Olympic-sized swimming pools' worth of untreated wastewater every day.

WASE aims to be a one-size-fits-all modular containerised wastewater treatment solution, allowing communities and companies to manage and benefit from their waste in a sustainable and self-sufficient way. Through an electro-methanogenic reactor (EMR) process the system can recover useful products from waste streams, including energy in the form of biogas, clean water, and fertiliser for agriculture.

The focus of the project was on further commercial validation through designing and developing a pilot system for implementation before a full system is introduced in 2022. Initial research was conducted into anaerobic digestion efficiency and enhancement, looking into three main areas; tank design, heating and mixing methods, helping to inform later design decisions. Working directly with the design team, calculations were carried out to determine parameters for heating and mixing requirements, in addition to design and development work on the overall system process layout and the fluid dynamics within the treatment tank. Once parameters were determined, quotations and advice were obtained from companies for components in order to develop accurate OPEX and CAPEX costings, as well as the preliminary CAD design of the system, which aids in design decisions for manufacturing and assembly.

With the implementation of technology like WASE's, emissions and harmful pollution from waste streams can be significantly reduced, helping to work towards global initiatives for renewable energy, clean water and sustainable agriculture.



Rendering of WASE's containerised system

Fellow:
George Kelly, UK

Program Coordinator:
Elizabeth Collins, Scotland

Partner collaborators:
Aeran Jenkinson, George Fudge, Llŷr Anwyl, Faryal Rohail, Isabella Bulmer, Kyle Bowman, Marcelo Elaiuy, William Gambier, Thomas Fudge

This work was sponsored by:
Autodesk Foundation

This work is in collaboration with:
WASE Ltd.
<https://wase.co.uk/>



6 CLEAN WATER AND SANITATION



Amped Innovation

Development of a High Autonomy Solar Fridge

Around half of the population in West Africa does not have access to electricity due to limited grid infrastructure, and for those who do have access, it can be unreliable and expensive. As a result, food conservation becomes challenging and the resulting impact on communities is reduced nutrition levels and higher levels of food waste. It also has economic impacts on small businesses that sell beverages, fruit, vegetables, and other perishable products. Standard AC (Alternating Current) commercial freezers are not designed for these challenging energy conditions where high ambient temperatures increase electricity loads and result in quick temperature rises when the energy supply is lost. Solar DC (Direct Current) fridges have recently entered the market, however, many of these still do not fully address issues with affordability and performance. Amped Innovation's goal is to provide a low-cost solar DC fridge that can keep goods cooled overnight without an external energy supply.



Rendering of the WOWSolar Fridge in Fusion360

The aim of this project was to identify a way to deliver both low-cost and overnight cooling. Through thermal modeling and CFD (Computational Fluid Dynamics) analysis, solutions to these problems were developed, including a combination of enhanced air convection, a phase change thermal battery, and better insulation. The challenges of working with phase change for cold storage instead of large batteries are significant, but also well worth it since phase change costs 10 times less than lithium battery packs for the same energy storage. Through reverse engineering, the main manufacturing constraints affecting the performance of the evaporator were identified and were considered for the single-wall final evaporator design. Finally, the design was changed to allow for a transition from a high Global Warming Potential refrigerant to isobutane, a more eco-friendly solution without sacrificing cooling power. The design requirements were satisfied successfully and a CAD (Computer Aided Design) model incorporating these improvements was developed to provide the manufacturing team with the detail required for production.

With the help of modeling software, and through validation using simulation tools and prototyping, the final developed design offers a promising solution to the cooling challenges faced by individuals and businesses in communities with limited, unreliable, and costly energy access.

Fellow:

Francisco Plaza, Ecuador

Program Coordinator:

Elizabeth Collins, Scotland

Partner collaborators:

Kurt Kulhman, Co-CEO, USA; **Andi Kleissner**, Co-CEO, USA; **Denis Shcheglov**, Chief Mechanical Engineer, Russia; **Jeff Bennett**, Chief Marketing Officer, Sweden

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Amped Innovation

<https://www.ampedinnovation.com/>



**AMPED
INNOVATION**

**7 AFFORDABLE AND
CLEAN ENERGY**



M-KOPA

Battery Management Systems and Analytics for e-Mobility

This project aimed to help M-KOPA design an e-mobility technical solution, with a specific focus on the battery management elements. M-KOPA is a company that offers financing options to millions of customers who are underserved by traditional financial services, providing them access to life-enhancing products and services. The company now plans to introduce e-mobility solutions throughout Africa, as a way to provide sustainable means of transportation for the public by having clean, affordable e-bikes accessible through their innovative financing model.

Research was conducted into appropriate Battery Management Systems (BMS) for e-bikes, covering fundamental concepts of the systems, battery charging algorithms, supported features, and the commercial market. From this information a wiki was developed, simplifying the concepts of the BMS and providing a helpful guide for the different functions of M-KOPA who need to interact with the technology. It can also be used to help identify the appropriate technology required for their application.

Another objective of the project was to create a technical dashboard for the BMS system, which would display e-bike data in a clear and intuitive way, for both M-KOPA engineers and end-users. This dashboard was created using the Power BI application, which provides interactive visuals for dashboard creation. The end product provides users with a better understanding of their e-bike's KPI metrics such as state of charge, state of health and distance traveled, which can assist in the maintenance of their vehicles.

With this wiki and dashboard, M-KOPA will be able to better monitor their products and have an understanding of the essential features of e-bikes which will assist in the further development of their e-mobility technology.



M-KOPA e-mobility products

Fellow:

Alaa Emadeldin Selim, Egypt

Program Coordinator:

Elizabeth Collins, Scotland

Partner collaborators:

David Damberger, Managing Director of M-KOPA Mobility and M-KOPA Labs, Kenya

Katherine Owens, Head of Labs at M-KOPA Solar, UK

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

M-KOPA

<https://m-kopa.com/>

M-KOPA

7 AFFORDABLE AND CLEAN ENERGY



SolarBuddy

Advancing Low-Cost Solar Cooking Technology

FamilyBuddy is SolarBuddy's newest solution to provide solar-powered cooking, cooling and lighting technology to families experiencing energy poverty worldwide. This project focused on designing the cooking element of FamilyBuddy, with the aim of fitting within SolarBuddy's model of Learn, Make, Illuminate, that requires benefactors across the world to be involved in learning about and assembling technological solutions that will be gifted to families in energy poor communities. Globally, the World Health Organization reports that around 3 billion people cook using polluting sources which can result in illnesses such as pneumonia, cancer, and heart disease caused by household air pollution. This cookstove seeks to enable families to cleanly cook without fossil fuel resources in a low-cost, environmentally friendly, simple, and resilient package while saving time spent collecting cooking fuels.

The proposed design for the cooking component of FamilyBuddy offers an 18cm electric element powered by 640W of monocrystalline solar panels and a lithium-iron phosphate back-up battery pack to power the stove in all time settings. This uniform solution is intended to be deployed worldwide as a one-size-fits-all solution. The design focuses on modularity as a way for easy assembly and local repairability, only requiring a single screwdriver and wrench to completely assemble and disassemble the cookstove. Additionally, every component works to reduce the environmental footprint of the device by allowing for a variety of different upcycled materials to be used, such as denim insulation made from old overalls or jeans to protect the electrical components from the generated heat, or a countertop made from old solar panels.



Rendering of the electric cook stove with solar panels

SolarBuddy's vision is to deliver 250,000 FamilyBuddy's over a five-year period to prove its feasibility and show the positive impacts that utilizing solar electric power for cooking and cooling can have globally.

Fellow:

Brandon Simons, USA & South Korea

Program Coordinator:

Elizabeth Collins, Scotland

Partner collaborators:

Simon Doble, Global CEO & Founder, SolarBuddy, USA

Joanna Cantwell, Director Stakeholder Engagement, SolarBuddy, Australia

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

SolarBuddy

<https://solarbuddy.org/>



7 AFFORDABLE AND CLEAN ENERGY



Autodesk Foundation

Advancing the Use of Design and Manufacturing Technology in Startups and Nonprofits

The Autodesk Foundation facilitates grants and impact investments, donated Autodesk technology, and Autodesk employee volunteer hours to support nonprofits and startups to scale innovations – advancing a more sustainable, resilient, and equitable world. Through desk research and interviews with technical leads and founders across the Autodesk Foundation portfolio, this project sought to identify opportunities to improve and facilitate technology adoption and training in the product design and manufacturing space.

Interviews were conducted with 17 organizations to understand technology and training gaps which could be addressed by the Autodesk Foundation. From these interviews, additional technical assessment calls were scheduled to further scope software training requirements, and organizations were advised on technical software solutions. Internal tools and documentation were also streamlined by creating a customer journey map detailing post-investment engagement pathways, organizing internal data, and collecting feedback on product usage and experience.

Increased interviews and in-house technical capacity provided through the project resulted in more software donations, technology assessments, and tailored training sessions for the startups and nonprofits in the Autodesk Foundation portfolio. From the research conducted, a number of recommendations were formulated for improved customer experience. In addition, the marketing team was able to utilize the data for future content and impact metrics. Overall, this work contributed to the Autodesk Foundation's initiatives supporting emerging startups and nonprofits to scale solutions to the world's most pressing social and environmental problems.

We drive impact in 4 ways



Focus on early-stage startups and social enterprises



Provide risk-tolerant capital



Offer in-kind services by leveraging Autodesk Inc.



Scale transformative technologies

Fellow:

Danna Xue, USA

Program Coordinator:

Elizabeth Collins, Scotland

Partner collaborators:

Bobbie Casey, Partner Success Manager, USA

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Autodesk Foundation

www.autodesk.org



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



Moving Health

Modeling Existing Ambulance Tricycle Prototype and Proposing Strategies for Operations of Health Transport Services in Sissala East District, Ghana

In the rural district of Sissala East in Ghana, small villages and hamlets are connected over long distances by poorly maintained dirt roads that make travel between them very difficult. The challenge of transport is therefore one of many barriers for locals to get access to adequate healthcare. Moving Health, formerly known as The Okoa Project, aims to provide emergency transport between villages and the local health centers, and the health centers and the central hospital in Tumu, Ghana. Moving Health's local team has manufactured several tricycle ambulance prototypes that service the district, and they are working closely with communities, community health professionals, and local partners to expand their impact.

The work in partnership with E4C involved conducting field research to understand the local context and then documenting and modeling a version of the existing tricycle ambulance in Fusion 360 that combined the components that were working best for each of the built prototypes. In parallel to this work, a strategic document was developed to offer an outside perspective to the current operations of the tricycle ambulance service, proposing recommendations for how Moving Health may increase their impact and become more sustainable. The outputs from the Fellowship also include recommendations for best strategies to follow in the creation of a fabrication manual, to be used as a resource when their ambulance design is complete and ready to be manufactured at a larger scale.

Moving Health will benefit from this work by using and building on the Fusion 360 model to further improve the design of their ambulance, and by consulting the strategic document as they further their work in Sissala East and other rural districts in Ghana.



A rural ambulance design in Tumu, Ghana

Fellow:

Sally Aba Akyere Osafo, Ghana

Program Coordinator:

Elisabeth van Overbeeke, Canada

Partner collaborators:

Emily Young, Chief Executive Officer;
Nana Damoah, Country Director; **Isaac Quansah**, Chief Technology Officer;
Yahaya Basuglo, Program Manager;
Ambra Jiberu, Engineering Lead;
Sofianu Moru, Engineering Lead

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Moving Health

<https://www.moving.health/>



Moving Health

SAVING LIVES, ONE RIDE AT A TIME

9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



Bridges to Prosperity

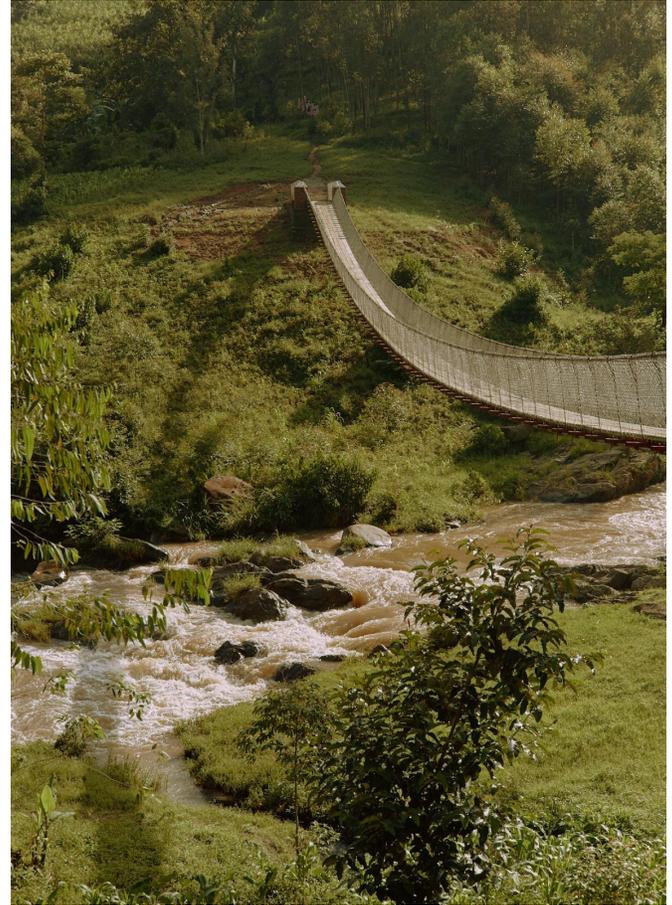
Impact of Rural Trailbridges on Adjacent Infrastructure in East Africa

Lack of access to critical services due to a lack of transportation infrastructure (such as bridges) is the root cause of poverty for nearly one billion people globally. With a motivation to break the cycle of extreme poverty, Bridges to Prosperity (B2P), since 2001, has completed more than 370 bridges in over 20 countries, granting last mile access to more than 1.3 million people.

This study seeks to assess the impact of trailbridges on adjacent paths and roads by analyzing and measuring the change volume before and after bridge construction using publicly available satellite imagery. This project is particularly important in a field where vehicular transportation is frequently prioritized over pedestrian and motorcycle transport. The evaluation methodology involves manual feature extraction and measurement of the areas of visible foot paths, before and after the trailbridges were constructed at 65 sites within the East African countries of Rwanda and Uganda.

The study concludes from preliminary investigations that trailbridges create improved access, and in some areas spur mobility focused infrastructure developments such as Umuganda (“coming together in common purpose”) community road maintenance projects. This is justified by observed and measured changes in 40 out of the 65 analyzed sites, where footpath areas increased on average of about 68.77% within a 3-year average timespan between the data collection periods.

Additionally, the possibility of further analysis to draw a correlation between the improved access created through the provision of trailbridges, and socioeconomic growth within the geographical regions of the project sites, is proposed for future studies.



A B2P trailbridge improving access across a river

Fellow:

Abdul Rashid Kanda Mussah,
Ghana

Program Coordinator:

Elisabeth van Overbeeke, Canada

Partner collaborator:

Abbie Noriega, B2P VP of
Evaluation

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Bridges to Prosperity (B2P)

<https://www.bridgestoprosperity.org/>



**Bridges to
Prosperity**

11 SUSTAINABLE CITIES
AND COMMUNITIES



BuildChange

Automating Structural Retrofits for Low-Income Households in Bogota, Colombia

Substandard housing is a widespread problem throughout Colombia, occurring most often in urban areas where homes are typically constructed without technical specifications. Due to increasing rural/urban migration, massive neighborhoods of these poorly built structures have emerged, leaving large communities vulnerable to environmental risks such as earthquakes, floods, and landslides. Build Change, working together with Colombia's Ministry of Housing, has been working to employ Autodesk software to develop tools that automate the design of structural retrofits for these vulnerable homes.

This fellowship sought to support Build Change's efforts, providing a particular focus on data processing and document production of the automated retrofitting design process. Using the Dynamo visual programming environment in Revit, the team developed 12 different design scripts which interpreted, analyzed and prescribed retrofits for existing models of homes in nearby informal settlements. Depending on the desires of the homeowner, the Dynamo scripts can reinforce existing structural systems, add openings and pathways, or even add additional stories of construction. In order to ensure that the knowledge and tools generated throughout the fellowship is carried on by the Build Change team, software learning tools were crafted and collective learning opportunities were curated for the Build Change staff.



Substandard housing in high seismic zones without technical specifications

Build Change is currently preparing to transfer the Revit and Dynamo tools to the Colombian Ministry of Housing for pilot testing, improving their capacity to rapidly and efficiently provide structural upgrades and habitability improvements to families in need.

Fellow:

Valentina Ospina, Colombia

Program Coordinator:

Charles Newman, USA

Partner collaborator:

Allison Young, BIM Technologies

Specialist;

Stefano Pompei, Technology for Engineering Project Manager

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Build Change

<https://buildchange.org/>



11 SUSTAINABLE CITIES AND COMMUNITIES



BuildX Studio

Quantifying Embodied Energy: Considering Carbon Footprints in Schematic Design for Modular Housing Projects

BuildX Studio is a Nairobi-based design-build practice that is currently working to improve their workflow from design to construction. One project in particular in the BuildX portfolio, the MODUL (Model for Decarbonised Urban Living) project, seeks to develop a roadmap for low-cost, environmentally sustainable housing solutions that can be scaled up to achieve national priorities for dignified housing for all.

The Engineering for Change fellowship sought to support and refine the BuildX workflow through the introduction of Revit, for Building Information Modeling; and Tally, a Revit plugin that allows designers to quickly quantify the environmental footprints of design schemes. With the BuildX team having identified Cross Laminated Timber (CLT) as a low-carbon building material that would be a good fit for the Kenyan housing market, research into the material and assessments of the software platforms led to the development of families for CLT architectural systems. Additionally, Tally was used to quantify the carbon footprints of similar CLT products from various global suppliers, measuring the embodied carbon footprint of the design over the complete life cycle of the product.

This research was also packaged into educational videos and documents to ensure an efficient transfer of knowledge to the BuildX team, giving the firm the tools to employ the software platforms to further the MODUL project and other initiatives in the BuildX portfolio.



Rendering of a modular housing project

Fellow:

Kalimba Rugamba Nicolas,
Rwanda

Program Coordinator:

Charles Newman, USA

Partner collaborator:

Wekesa George, BuildX Studio,
Kenya

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

BuildX Studio

www.buildxstudio.com/



11 SUSTAINABLE CITIES
AND COMMUNITIES



EarthEnable

Dignified Rural Home Design in Rwanda Using Adobe Block

Rural houses in Rwanda are typically constructed out of adobe blocks, a material freely available because of the abundant clay in the soil. Rural households have low incomes and construct very basic dwellings that often have flaws that cause problems for the health and general comfort of the occupants. EarthEnable has been actively working in Rwanda to install earthen floors in rural houses that is one element that greatly improves interior conditions, and they are interested in expanding and exploring implementing the design of adobe houses to further their impact.



Example of rural home design in Rwanda

The team conducted 25 household surveys in two districts to discover what were the greatest challenges that households face with their houses. The results showed that overheating, dampness, and poor ventilation were key challenges among others. In response to these specific needs, the team designed a prototype sample house and a catalogue of design details to address many of the challenges, with the hope that they can be implemented in a future initiative for improving the construction of rural houses.

EarthEnable will be able to use the catalog to construct a sample home and also make it available to households who may decide to implement the full design or particular details depending on their budget.

Fellow:
Simeon Bunani, Rwanda

This work was sponsored by:
Autodesk Foundation

Program Coordinator:
Elisabeth van Overbeeke, Canada

This work is in collaboration with:
EarthEnable
<https://www.earthenable.org/>

Partner collaborator:
Athanase Nzayisenga, Global R&D Manager; **Sylvere Nsengimana**, Rwanda R&D Manager; **Mizero Jeanne D'Arc Akayezu**, R&D Officer



11 SUSTAINABLE CITIES AND COMMUNITIES



Habitat for Humanity International

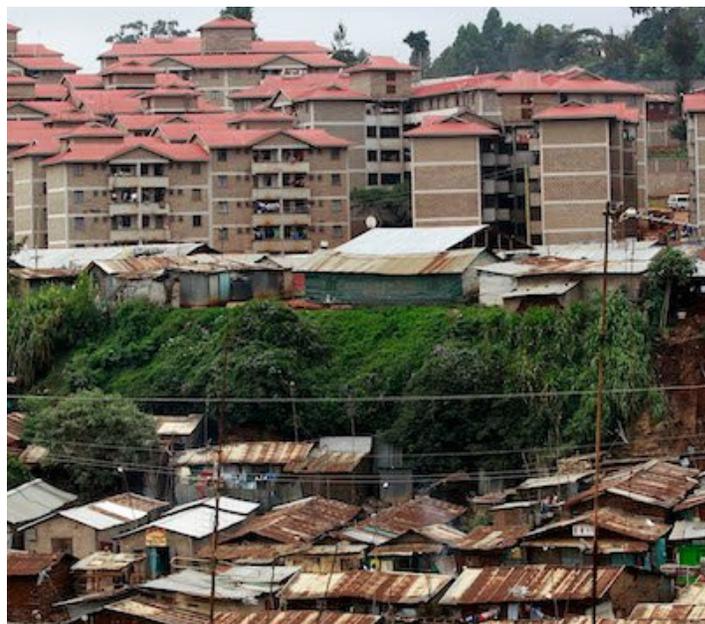
Circular Economies and Affordable Housing in Kenya

The construction industry consumes more raw materials than any other sector in the global economy, accounting for more than 25% of the global total carbon emissions. Due to its current level of industrialization, Kenya does not have a large ecological footprint, having recorded a per capita CO₂ emission of 0.31 metric tonnes in 2018, less than 2% of the United States' emissions for the same year. In fact, like other African countries, indigenous building practices, which have minimal adverse environmental impacts, are still present in much of the country. Nevertheless, in Kenya, strides have been made towards mitigating adverse effects on the natural environment by embracing practices and products towards circular economies. Much of this progress is due to the increased participation of stakeholders, e.g., state actors, private industries, and various interest groups.

In partnership with Habitat for Humanity, this research set out to identify sustainable housing solutions that enable circular economies in Kenya. This report provides a landscape analysis of main opportunities, trends, private initiatives, barriers, key stakeholders, and policy options to promote and develop the circular economy in affordable housing in Kenya.

To achieve this objective, secondary research was completed to identify main trends and solutions, combined with twelve interviews with experts of the sector, with representation from the public sector, private sector, NGOs, and academia. Guided by the ReSOLVE Framework, data were synthesized to assess barriers and recommendations categorized as follows: (1) Circularity within the construction value chain, (2) Natural Construction Materials, and (3) Enablers and Barriers to Circularity.

Overall, this report presents a variety of initiatives and technologies aimed at achieving a circular economy, with an emphasis on affordable housing. Important insights are discussed, including the importance of participatory community approaches to housing development. Further, there already exists a vast array of technologies suited for developing affordable housing and financial platforms that serve the bulk of the population in the informal sector; these require support to scale at feasible speeds.



Housing in Kenya
(Source: Reuters/Thomas Mukoya)

Fellow:
Guy Mambo, Congo

Expert Fellow:
Patrick Sours, USA

Partner collaborators:
Jennifer Oomen and Jacob Simwero

This work is in collaboration with:
Habitat for Humanity International
www.habitat.org/our-work/terwilligercenter-innovation-in-shelter



Terwilliger Center for Innovation in Shelter

View the full report: <https://www.engineeringforchange.org/research/circular-economies-affordable-housing-kenya>

11 SUSTAINABLE CITIES AND COMMUNITIES



Habitat for Humanity International

Circular Economies and Affordable Housing in Mexico

As a significant contributor to climate change, the housing sector (including construction and use) is responsible for 32% of Mexico's greenhouse gas (GHG) emissions, producing 40% of the country's waste. Nationwide, construction and demolition produce 6.1 million tons of waste each year. Meanwhile, by 2030, an estimated seven million additional houses are needed to fit the country's growing population demands. This disparity specifically affects the most vulnerable communities, where almost 40% of all homes are considered inadequate.

For these reasons, Habitat for Humanity, through the Terwilliger Center for Innovation in Shelter, is looking to facilitate more inclusive and sustainable housing solutions within market systems. This report provides a landscape analysis of main opportunities, trends, private initiatives, barriers, key stakeholders, and policy options to promote and develop the circular economy in affordable housing in Mexico.

We combined desktop research and semi-structured interviews with more than 15 experts in the local housing ecosystem, representing the public sector, private sector, non-governmental organizations (NGOs), and academia. To facilitate the research process, we used the ReSOLVE Framework in combination with the concept of waste hierarchy to assess the most suitable options for waste management. The investigation determined four main strategies and trends ongoing in Mexico to improve circularity in the housing sector: (1) improving the reuse and recycling of building materials within its value chain; (2) developing building materials by using recycling plastics; (3) shifting towards innovative construction systems that use industrialized production processes; and (4) increasing the use of natural and bio-based materials that have a less ecological footprint. The outcomes of this research suggest:

- Specific technologies can improve circularity in the housing sector, reducing the environmental impact while providing affordable and inclusive solutions.
- There are vast opportunities and significant impact in supporting initiatives that aim to reduce, reuse, or recycle construction and demolition waste.
- Financial and social barriers block the penetration of circular solutions like using plastic building components or industrialized construction systems.
- A primary barrier to decarbonizing the production process of high-carbon-intensive materials is the availability and affordability of these innovative solutions, as well as their appropriate business model.



Construction in Mexico

Fellow:

Martin Ignacio del Pino, Argentina

Expert Fellow:

Patrick Sours, USA

Partner collaborators:

Jennifer Oomen, **Ana Karen**

Medina, **Juan Pablo Vargas**, and

Fernando Medoza

This work is in collaboration with:

Habitat for Humanity International

[www.habitat.org/our-](http://www.habitat.org/our-work/terwilligercenter-innovation-in-shelter)

[work/terwilligercenter-innovation-in-shelter](http://www.habitat.org/our-work/terwilligercenter-innovation-in-shelter)



Terwilliger Center for Innovation in Shelter

View the full report: <https://www.engineeringforchange.org/research/circular-economies-affordable-housing-mexico>

11 SUSTAINABLE CITIES AND COMMUNITIES

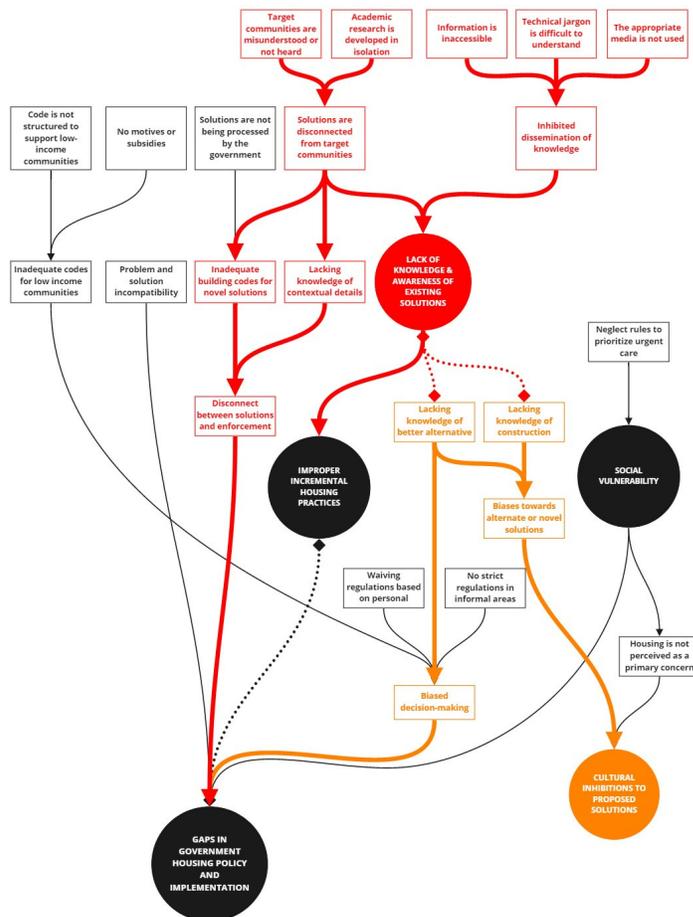


Penn State University

Engineering Design Recommendations for Resilient Housing: A Case Study of Dar es Salaam in East Africa

Through a collaboration with Penn State University and Engineering for Change, this research report assesses the barriers preventing effective application of housing solutions for improving flooding resilience for housing within the context of Dar es Salaam, Tanzania, which was selected due to its rapidly increasing population and vulnerability to floods. Five key obstacles that inhibit solution effectiveness are: social vulnerability, improper incremental housing practices, a lack of knowledge and awareness of existing solutions, cultural inhibitions to proposed solutions, and gaps in government housing policy and implementation.

Desk research of academic papers, reports, and publications revealed existing solutions addressing disaster risk reduction and management, disaster response tools and guides, factors contributing to social vulnerability of communities in flood-prone areas, and locally available materials. Interviews with stakeholders from different perspectives (humanitarian response, local and foreign material research, and non-government organizations) revealed nuances in barriers, highlighting areas where existing solutions fail. A mapping of barrier cause-and-effect factors revealed lack of communication between stakeholders to be a common denominator accentuating barriers to solution effectiveness. The report concludes with a proposed realignment of existing solutions that specifically target communication between stakeholders, identifying four categories of approach types: (1) research and academic, (2) government, (3) non-government organization, and (4) collaborations between multiple stakeholders.



Flow tree of multiplier effect mapped across barriers to improving flooding resilience

Fellows:

Ali Ghazvinian, Iran

Tiffanie Leung, USA

This work is in collaboration with:

Penn State University

<https://global.psu.edu/>

Expert Fellow:

Khaoula Trigui, Tunisia



PennState

Partner collaborators:

Dr. Esther Adhiambo Obonyo, Director of the Global Building Network and Associate Professor at Penn State University

View the full report:

<https://www.engineeringforchange.org/research/engineering-design-recommendations-resilient-housing-case-study-dar-es-salaam-east-africa/>

11 SUSTAINABLE CITIES AND COMMUNITIES



United Nations High Commissioner for Refugees (UNHCR)

Development of Templates to Support an Integrated Settlement Planning Framework in the Context of Refugees, Humanitarian, and Conflict Affected Areas

In recent years, UNHCR has reappraised humanitarian settlement planning within the context of displacement crises. The Master Plan Approach (MPA) to settlement planning consisting of its ten guiding principles and annexed support tools is UNHCR's guiding framework for the spatial design of humanitarian settlements. It establishes a unique response vision aligned to national, sub-national, and local development plans with the aim to facilitate linkages between multi-sectoral humanitarian responses and long-term development efforts.

In an effort to operationalize the MPA, the Technical Support Section (TSS) at the UNHCR has focused this work in nine country operations, primarily in East Africa, to develop an agreed Basic Package (BP) of settlement planning information to inform a spatial settlement master plan. The TSS team has also created a standard drawing folder system for hosting drawings in each operation and replicated them on their Settlement Information System (SIP).

The aim of the project was to provide technical support in the delivery of settlement planning tools and templates as a key component for operationalizing UNHCR's integrated settlement framework (MPA) through the delivery of the Basic Package initiative which comprises five drawings (maps and site plans) and six documents.

The Fellows supported UNHCR through further definition, content development, purpose, and development of the five drawings and six documents that constitute the Basic Package list. The standard drawing templates included scales, pen weights, coordinate systems, settings, symbols, and other critical references, while the standard document templates included proposed report outlines and descriptions of the proposed contents in addition to standard assessment forms where needed. For example, key templates such as that on Natural Features and Key Ecological considerations support TSS's efforts in the greening of its operations and mainstreaming climate change considerations within its settlement planning initiatives. These drawings and documents will contribute towards sustainable settlements planning, as UNHCR continually integrates humanitarian emergency approaches into multi-sectoral, longer-term, and resilient interventions that result in improved environmental outcomes.



*Kebribeyah Refugee Camp, Ethiopia
(Source: UNHCR)*

Fellow:

Dima Abu-Aridah, Jordan

Program Coordinators:

Elisabeth van Overbeeke, Canada

Charles Newman, USA

Partner collaborator:

John Wain, Senior Emergency Shelter Officer, Switzerland

Philippe Alexandre Long, Associate Urban Planning Officer, Switzerland

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

United Nations High Commissioner for Refugees (UNHCR)

<https://www.unhcr.org/>



11 SUSTAINABLE CITIES AND COMMUNITIES



BamCore

From CAD to CAM: Streamlining Workflows for Custom Prefabricated Construction

The Autodesk partnership with BamCore sought to support the BamCore team by identifying and implementing software-based automation tools to further streamline the company's design to fabrication workflow. Based in California, BamCore was founded upon the goal of re-imagining the fabrication of our built environment towards a more cost-efficient and sustainable future. To achieve this, the Bamcore team employs a panelized structural load bearing bamboo system through a workflow that allows custom designs to be realized through an industrialized prefabrication process. This results in building packages that are fast and easy to assemble; and projects with a lower embodied carbon footprint than conventional construction systems.

The fellowship looked at specific moments in the workflow that were time consuming and could benefit notably from increased automation. Using Autodesk's Revit program and a third party fabrication plug-in, AGACAD, the development of shop drawings for field assembly and the categorization of timber components were identified as areas where automation could reduce time, cost, and human error. AGACAD's Smart Dimensioning tool proved particularly useful. Over the course of the fellowship, the tool was clarified and customized with precise configurations for BamCore's needs, which now speeds up the production of shop drawings by generating automatic dimensions for all elements within the panelized system. Additionally, the SortMark tool, previously unused by BamCore's team, was adopted and employed with appropriate configurations to suit Bamcore's needs. This tool now facilitates an automated process of marking and categorizing each timber framing component, guiding contractors in material placement and assembly. Both of these systems were packaged into educational materials that can support BamCore staff and further build the company's foundation of knowledge.



Prefabricated construction materials

Fellow:

Maajabu Alleluia Tito, Rwanda

Program Coordinator:

Charles Newman, USA

Partner collaborators:

Brenden Morton, Director of Platform and Job Engineering

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

BamCore

<https://www.bamcore.com/>



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



Industrial Sewing and Innovation Center (ISAIC)

Virtual Training and Assistance in the Apparel Industry

This collaboration with ISAIC, a US-based NGO dedicated to responsible production of high-quality and sustainable garments, aimed to identify and test a virtual delivery method for remote training and assistance in machine maintenance and problem-solving. The virtual method will be part of a system for certified apprenticeship training that will articulate competencies in a more relevant manner within the sewn goods industry. The study of possible methods for on-demand machine repair or training was conducted by looking at commercially available tools used previously in other industries.

The need for a remote assistance solution comes as a result of a series of factors: a scarce number of expert technicians in specific countries, the frequent need for in-person assistance, a strong interest in production and problem-solving optimization, and the intention to work more sustainably are only a few.

During the collaboration a group of stakeholders was interviewed to provide a better understanding of how the technology should adapt to the needs of the sewn goods industry. A careful analysis of software and hardware tools presently available was conducted. Putting together the requirements communicated by stakeholders and the review of software-hardware options available, a subset of tools were selected for an in-depth, hands-on study. Team members from ISAIC and E4C carried out virtual assistance test calls to become familiar with the technology, and ultimately identified the most appropriate tools needed for the industry.

The work was completed with a preliminary analysis of how these remote training and assistance tools could be made available to other partners in the U.S. By bringing tested smart solutions to the industry, ISAIC is contributing to making the fashion industry more efficient and sustainable.



A remote assistance system will help in the communication between local machine technicians and remote experts, and it will also be useful for remote training of sewing skills

Fellow:

Maria Nieves Brunet, Paraguay

Program Coordinator:

Carolina Rojas Echeverri, Panama

Partner collaborators:

Alex Allen, Production Manager, USA; **Alex Stchekine**, Technical Facilities Manager, USA; **Jen Guarino**, President & CEO, USA

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

Industrial Sewing and Innovation Center (ISAIC)

<https://isaic.org/>



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



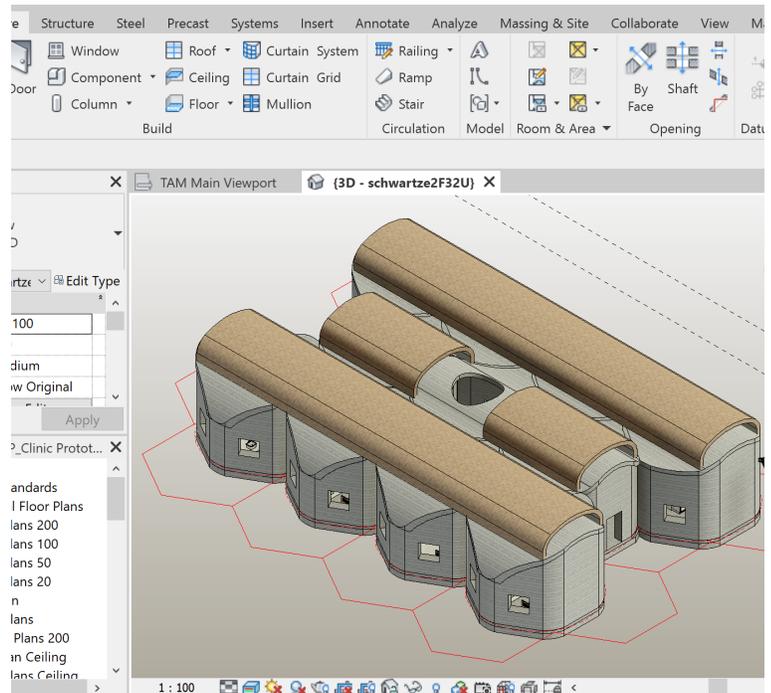
TAM Associati

From Product to Project: Scaling the Gap from BIM to Full Scale 3D Printing

3D printing technology has begun to revolutionize the way we can think about developing the built environment in resource-scarce settings. As the technology stands, however, it is impossible to print on-site from foundation to roof with a single printer. There is no proven design, system, or prototype that shows how the technology can be quickly and affordably employed in these environments. In partnership with TAM Associati, this fellowship aimed to clarify challenges and to identify constraints pertaining to this challenge.

The project began with identifying the physical constraints of printing a medical clinic in either Sudan or Uganda. The team chose to work with the Italian Company, WASP, and their “Crane” printer, which has a printing radius of 4 meters and height of 3 meters. Each print area, or “module”, had to interlock to accommodate the entire program – from waiting spaces to examination rooms – to form the whole clinic. Due to material constraints, the roof could have a minimum pitch of 30 degrees while seamlessly unifying all of the modules. Once a prototype was designed to fit within these constraints, the project turned to the challenges of scale and digital translation across software platforms. The Revit model was unified into a single solid form and exported into Fusion 360, where it could be made into a mesh. The mesh was then determined to be in a suitable format to be reinterpreted into a G-Code that the WASP team can use to guide their Crane printer.

Questions still remain about the logistical constraints of construction, ranging from labor concerns to the sourcing of material. The fellowship, however, was able to support this investigation into the technology and helped clarify its potential to help those in crises around the world.



Rendering of 3D-printable clinic model in Revit
(Source: Emily K. Schwartz)

Fellow:

Emily K. Schwartz, USA

Program Coordinator:

Charles Newman, USA

Partner collaborators:

Enrico Vianello, Junior Partner, TAM Associati; **Raul Pantaleo**, Senior Partner, TAM Associati; **Debora Buccino**, Assistant, TAM Associati; **Claudia Ballarin**, Architect, TAM Associati

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

TAM Associati

<https://www.tamassociati.org/>



12 RESPONSIBLE
CONSUMPTION
AND PRODUCT



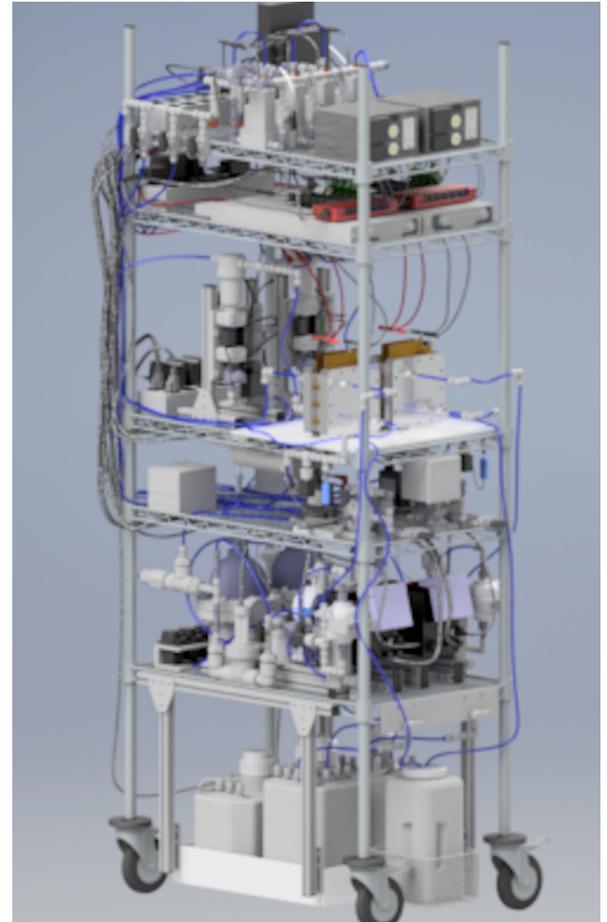
twelve

CAD Modelling and Version Management of Electrolyzer Test Systems

As a company, twelve is working to combat climate change through carbon transformation where they turn CO₂ into essential products, such as jet fuel, to create a carbon neutral world.

The primary project during the summer collaboration with twelve was building a model of their CO₂ electrolysis test system, using Inventor, to enable more efficient prototyping. This required modelling parts from specification sheets or dimensions provided by the on-site engineering team, utilizing pre-made models from manufacturer's websites when available, and assembling each component into a series of subassemblies. With each complete subassembly, the full test stand model continued to develop, leading to the final stages of this project: routing the plumbing and wiring. With help from the on-site engineering team and test stand documents, the flexible tubing was added and routed between the appropriate subassemblies using the Tube and Pipe feature in Inventor, and the wiring was added using the Cable and Harness feature. In addition to the test stand model, some smaller projects like creating a custom title block for technical drawings, custom part drawings, and mounts for a series of peristaltic pumps and a water filter, were also completed. To design the mounts, the engineering team went through a simple, iterative design process to brainstorm potential solutions, choose a design, create a prototype and test its feasibility.

These projects, in particular the test stand model, will contribute to more efficient prototyping in the future. The team can use the virtual models of the stand and each individual part to more easily design custom mounts, hold design reviews, assist in onboarding, and verify plumbing and wiring routing.



*Full test stand model completed in Inventor
(Source: Kyla Strickler)*

Fellow:

Kyla Strickler, USA

Program Coordinator:

Elizabeth Collins, Scotland

Partner collaborators:

Austin Flanagan, Engineer; Ashley Eggart, Engineer; Dave Whittaker, Senior Engineer; Carter Haines, Director of Advanced Capabilities; Ted Myers, Engineer; Zoe Fiddler, Engineer

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

twelve

<https://www.twelve.co/>

—twelve

13 CLIMATE ACTION



SCORE International

Developing 3D-Printed Structures for Novel Coral Restoration Method

This engineering collaboration aims to assist SCORE International, Inc. (SCORE) in identifying optimal design characteristics for coral delivery mechanisms used to sustainably restore coral reefs at scale. SCORE has pioneered restoration through sexual reproduction methods by creating novel tools that leverage coral spawning events where eggs and sperm are released and fertilized to form genetically unique coral larvae. One such tool is the Coral Larvae Seeding Unit (SU), a manufactured structure designed to provide a habitat where coral larvae can mature and then be outplanted to the reef by wedging the unit into cracks and crevices. Still, outplanting corals by hand is a labor-intensive process and not scalable. SCORE aims to upscale this technology by enabling scattering of the SUs from the surface of the water or from an Automated Underwater Vehicle possible. To achieve this, the physical characteristics affecting the retention of the SU on the reef must be better understood.

The E4C fellows focused on understanding how varying design characteristics (size, shape, mass, etc) of the SUs can promote retention on the reef. The Fellows analyzed the initial retention testing data from a multifaceted Wind-Wave Storm simulation tank and determined the testing methodology needed to be standardized to yield more conclusive results. Thus, the objectives of the fellowship dynamically evolved to modify the retention testing procedure and specific SUs being tested, and prepare and perform a second Retention Test. A second Retention Test was carried out with support from the Fellows and the collaboration was finalized with the production of a comprehensive testing document and an initial analysis of the resulting data.

By improving the way SCORE technologies are being tested, this collaboration contributed to the organization's long-term goal of refining its methods and building tools that make scaled restoration affordable. SCORE's methods and approach of sharing the technologies with a global network of coral restoration partners have the potential to accelerate restoration results in the race to save corals.



Photo of Seeding Units resting in a basin where coral larvae can settle and grow on the SUs until they are ready for outplanting (Source: SCORE, International)

Fellow:
Minh Nguyen, USA

This work was sponsored by:
Autodesk Foundation

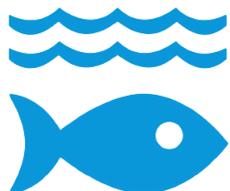
Program Coordinator:
Carolina Rojas Echeverri,
Panama

This work is in collaboration with:
SCORE International, Inc.

Partner collaborators:
Miles McGonigle, Project
Engineer, USA



14 LIFE
BELOW WATER



WeRobotics

Aerial Release of Mangrove Seeds to Support Coastal Ecosystem Restoration

This engineering design project with WeRobotics is meant to feed into a high-level plan to implement drones for the reforestation of different mangrove species zones worldwide. The research aims to assist the development of an attachable mechanical system for mangrove seeds release. Mangroves are one of the top three carbon-capturing ecosystems on Earth but in recent decades forested areas have been reduced due to the shrimp aquaculture industry, indiscriminate felling, and climate change. Reforestation efforts have increased in many parts of the world, however, many species of mangroves grow in subtropical coastlines and estuaries that are often difficult to access for humans, and reforestation of large areas is constrained. Drones can be used as a tool to support individuals and local organizations in covering larger areas for mangrove reforestation and strategic planting, during a flight over afforestation areas a release mechanism can drop mangrove seeds in a distributed manner.

Through our collaboration with WeRobotics, we worked on the development of a modular design that can accommodate different types of mangrove seeds depending on the species requirement of the zone being afforested. For this project, we started by analyzing the current state of release system designs and interviewing key stakeholders to identify current problems faced when restoring mangrove ecosystems. Both activities allowed us to develop an initial list of key design requirements that we then used to determine design concepts. With our final design identified, we began an iterative process to test and refine our final design, a prototyping phase was conducted where mechanical components were 3D printed and actuators and sensors integrated to test the release mechanism. A final prototype was obtained and tested in a controlled environment.

In the future, the design we developed through this project can be scaled up to be integrated into WeRobotics drone-based solutions and tested under real conditions in an afforestation area. Technological tools such as aerial drones for afforestation can be an important ally to local and international organizations for successful and large-scale afforestation.



A WeRobotics drone with a payload box attached

Fellow:

Julian Krüger, Germany

Program Coordinator:

Carolina Rojas Echeverri, Panama

Partner collaborators:

Jürg Germann, Switzerland

This work was sponsored by:

Autodesk Foundation

This work is in collaboration with:

WeRobotics

<https://werobotics.org/>

**We
Robotics**

15 LIFE
ON LAND



Autodesk Foundation

Advancing Communities of Practice through a Technology Leadership Program

Since 2014, the Autodesk Foundation has facilitated funding, technology, and talent to nonprofits and startups to scale innovations advancing a more sustainable, resilient, and equitable world. The Autodesk Foundation is currently working on a pilot Leadership Program for technical experts from ~40 nonprofits and startups in the Autodesk Foundation portfolio. The program proposal has been drafted from a human centered design perspective with the direct participation of sixteen non-profit organizations and startups.

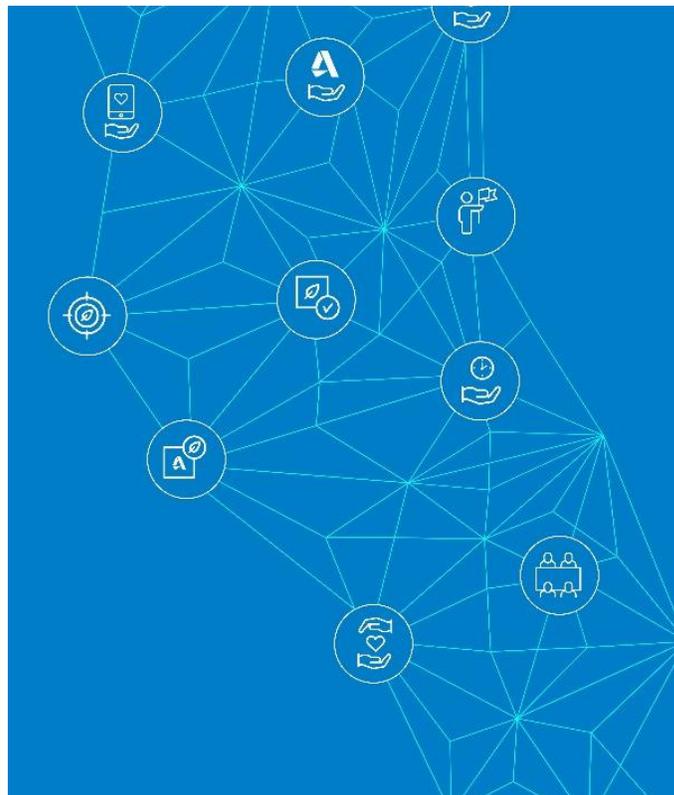
The Autodesk Foundation Technology Leadership Program seeks to build a community of practice among the Autodesk Foundation portfolio technology experts, optimize their impact within their organizations and equip them to drive engagement as innovators.

The input from interviews with fifteen nonprofit and startup leaders defined the structure of the program proposal. Key learnings from the leadership interviews included:

- Professional development opportunities are highly valued, but many organizations lack resources to formally offer in-house professional development programs.
- Inclusive leadership and communication skills were identified as the top two areas where technical experts in their organization could grow.
- Coaching, mentorship, networking, and formal training were also identified as key areas of development for technical experts.

Following interviews with leadership, the program offering was presented to the target audience, technical experts, which led to a highly refined program proposal.

The Autodesk Foundation Technology Leadership Program is an opportunity to equip technical experts around the world with skills to advance their path in influencing industry.



Structure of the Autodesk Employee Impact Program

Fellow:

Damiana Pacheco-Avilés, Ecuador

This work was sponsored by:

Autodesk Foundation

Program Coordinator:

Elisabeth van Overbeeke, Canada

This work is in collaboration with:

Autodesk Foundation

Partner collaborators:

Chelsea Bruno, Partner Success Manager, USA



17 PARTNERSHIPS FOR THE GOALS



**BY ENGINEERS,
FOR EVERYONE.**