Executive Summary of the project:

a. Introduce the project
The objective of this project is to build a solar-powered drip irrigation system on a school farm in Liberia (Jungle Farm) to address on the scarcity of the energy, water and food. The project consists of two phases. In phase one, we designed and developed the prototype of a solar-powered drip irrigation system in Ann Arbor, Michigan. This phase involved a literature review of drip irrigation systems and solar-powered water pumps and designing the controlling device for water pressure and the integrated drip irrigation system. In phase two, a team of four traveled to Liberia and started the process of building the solar-powered drip irrigation system in Jungle Farm with our partner organization, CRCA, and the local community. CRCA runs a school with thirty children adjacent to 4.5 acres of cropland that is intended to support meals for the school children. The construction of this drip irrigation system seeks to alleviate the lack of water during the 6 month dry season in Liberia and increase fruit and vegetable production on the farm through a clean, safe, and environmentally responsible technology.

b. Summary of the key impact/outcomes,
We built up a drip irrigation system on the one-acre high lands in Jungle Farm, Liberia. It will help to irrigate 20 crop and vegetable beds start from October 2017 and conserve water in four aspects.

Upon meeting with stakeholders from our partner organization, we were able to finalize the design for the system. The final design involved the construction of a 24 foot water tower, so we planned for the additional high to be added to the existing 12 foot tower on the farm. Construction of the tower was underway when we left Liberia. By the end of May it has already finished and ready to use. We were able acquire all of the necessary materials for the irrigation pipes and installed them on the farm with input from our partner organization CRCA as well as local community. We were able to test the pipes using the existing water tower and believe that the 24 foot tower will be able to generate enough gravitational force to maintain water pressure throughout the drip lines. It will be put into use from the October 2017. Local
partner and community were empowered with basic knowledge and skills to employ and maintain drip irrigation system. Contacts were made with several companies that retail solar panels in Liberia and we obtained estimates for the capacity of solar panels needed to power the system. Unfortunately, the type of pump that the system requires was not available in Liberia, which has delayed the completion of the installation.

c. Key stakeholders/partners
Our partner organization is the Christian Revival Church Association (CRCA). During our trip to Liberia, we worked closely with the CRCA program manager and the managers of the farm. CRCA’s mission is to achieve sustainable development at the community level by developing self-sufficient farms and school communities across their land. CRCA owns land near Monrovia, Liberia called Jungle Farm. Jungle Farm is a 15 acre area, where approximately 400 people reside.

(Photo by Tae Lim)
Progress towards the milestone according to the proposal:

We generally achieved all four stages of our project. The main part of building the solar-powered drip irrigation system in Liberia is finished (drip irrigation system) with the solar system still ongoing.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Done</th>
<th>Ongoing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature reviews</td>
<td>Ö</td>
<td></td>
</tr>
<tr>
<td>Design, develop and test the drip irrigation system</td>
<td>Ö</td>
<td></td>
</tr>
<tr>
<td>Travel to Liberia: build the solar-powered drip irrigation system</td>
<td></td>
<td>Ö</td>
</tr>
<tr>
<td>Evaluation and report</td>
<td>Ö</td>
<td></td>
</tr>
</tbody>
</table>

We achieved our first two stages of literature review and design of the solar-powered drip irrigation system in April and early May. We also revised our design and tailored it to match the local situation and requirements from the community when we traveled to the school farm in Liberia and discussed with our local stakeholders.

The stage of building the solar-powered drip irrigation system is still ongoing. We traveled to Liberia in this May and implemented the part of the drip irrigation system. Due to the limited availability of renewable energy devices in Liberia’s market, we are still negotiating and purchasing the solar pump for Jungle Farm.

Project achievements and impacts

- Design of solar-powered irrigation system.

  We developed our design of the solar-powered irrigation system both before and during our trip to Liberia. The finalized design for the solar-powered irrigation system can be seen below (Figure 1). In preparing the field trip to Liberia when we were in Ann Arbor, we developed a basic prototype of the drip irrigation system which includes a cascaded four water tank build on a water tower; a floating valve to control the process of solar-powered water pumping; and a design of the piping system for irrigation. We were not be able to build the prototype in the Botanical Gardens as we planned due to the restriction of both land and time. Instead, we spent our first two days in Liberia tailoring our design to the local situation (eg. sizes of beddings, distance to the water tower, crops and vegetables to be irrigated) and requirements from the community when we assessed the school farm and discussed with our local stakeholders.

  The finalized design of the solar-powered drip irrigation system achieves the goal of conserving water as well as replacing fossil fuels to clean solar energy. Through our design, water will been conserved in four ways: two-storied water tanks will store the overflow and prevent the waste; drip pipes pinpoint to individual crops or vegetables to maximize the water
use; each bed has an independent water valve to fully control water use; and vegetables and crops will be deliberately planted along the sloped land as to employ the secondary water flow that penetrates soil.

![Figure 1. Design of solar-powered drip irrigation system](image)

- Building the drip irrigation system in Liberia.

  By the end of the May, the main body of the drip irrigation system was completed and ready to be used during dry season. During the fortnight trip to Liberia in May, we built a one-
acre drip irrigation system on relatively high lands at Jungle Farm (Figure 2). We developed and assembled a drip irrigation piping system that consists of a main line and 20 sets of independent sublines across 20 vegetable and crop beds. Also, to complement the drip irrigation, we built up a 24 foot water tower with our local partners. By the end of May, the 24 foot water tower was also finished and linked to the main pipe line. We also tested the water flow of our drip irrigation system -- the 24-foot water tower has the capacity to reach the furthest line and irrigate five sublines at the same time. To prevent the accidental damage from school children, we also dug a shallow trench and buried our main PVC pipe lines underground.

We estimate that starting from October 2017, the drip irrigation system will be put into use. One acre of crops and vegetables, including corn, orange trees, bitter ball, cucumbers, potato greens, and watermelon, will be irrigated for more than 100 days.

Building the solar-powered system is the other part the complete design, which remains ongoing. The main reason for the delay is the unavailability of the solar pump in Liberia although solar panels and storage batteries are available. The alternative is to ship the solar-pump from the US to Liberia. However, the international import and shipment usually takes several months. We still have the will to finalize the solar system and the remaining plan is described later.

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![Figure 2. Build water tower and drip irrigation pipes.](image)

- **Capacity Building**

  As part of building the solar-powered drip irrigation system, we engaged our partner organization closely in our project and shared all our knowledge of the drip irrigation system with our local partners, CRCA, as well as local residents to empower them with the necessary knowledge and skills to maintain, upgrade, or even replicate the drip irrigation system (Figure 3). While the design of the solar-powered drip irrigation is tailored to the one acre high land that will be irrigated first in the coming year, the blueprint consists of drawings of every basic component of drip irrigation systems and pellucid concepts under the will of being easily understood, used and changed as well as expanded when needed. We showed our partner and community how the drip irrigation system is built and works and left the original design of drip irrigation system to our partner. By engaging in the whole process of purchasing, designing, and assembling the drip pipes and testing the drip irrigation system, our local partners acquired basic knowledge to employ the drip irrigation and maintain it accordingly. We also connect our
partner CRCA with our piping supplier in Liberia in case of further inquiry or need for maintenance.

Figure 3. Shared with the community and partners.

Describe the remaining plan.
To complete the solar powered drip irrigation system, we plan to travel again to Liberia in 2018. During our previous trip, we made contacts and had initial meetings with several solar companies in country. Before traveling again, our team will obtain price quotes from applicable companies and arrange for purchase of necessary equipment including a solar panel(s) and the pump. We plan to have a technician assist with the installation of the solar system. Before traveling, we also plan to develop a technical training for the system that can be shared with the community to better aid their understanding of the technology and enable them to maintain the system. Establishing the goals of an outreach curriculum to potentially showcase the drip irrigation system as a demonstration farm is also something we hope to discuss with our partner organization on the return trip.

Budget

<table>
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<tr>
<th>Item</th>
<th>Incurred/planned</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Water tower construction (materials and labor)</td>
<td>Incurred</td>
<td>$1700</td>
</tr>
<tr>
<td>Living expenses (4 people, 2 weeks)</td>
<td>Incurred</td>
<td>$700</td>
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<tr>
<td>Irrigation system piping</td>
<td>Incurred</td>
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<tr>
<td>Solar pump installation</td>
<td>Planned</td>
<td>$2400</td>
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<tr>
<td><strong>Grand total</strong></td>
<td></td>
<td><strong>$5000</strong></td>
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</tbody>
</table>
BEILU DUAN
Phone: +(1) 734-780-9412, Email: beilud@umich.edu

EDUCATION

University of Michigan, School for Environment and Sustainability (Ann Arbor, MI)

Sichuan University College of Biological Sciences (Chengdu, Sichuan, China)
- **Bachelor of Science**, Biological Science and Ecology, July 2014
- Academic Honor: Members of Pilot Project for Fostering Top-notch Students in Basic Science

EXPERIENCE

Sustainability Without Borders, UM, Liberia Team Leader (Ann Arbor, USA & Monrovia, Liberia) May 2016-May 2017
- Led regular students’ meetings and and coordinated with local Liberian partner NGO to design the solar-powered drip irrigation system and integrated livestock-farming system for school farms in Liberia.
- Developed project proposal and won Dow Distinguished Awards for Interdisciplinary Sustainability and National Energy Globe Award Liberia.
- Organized and Coordinated team field trip to Liberia to build the sustainable agricultural systems.

UN Environment-International Ecosystem Management Partnership, Intern (Beijing, China) June-July 2016
- Summarized and assessed the Ecosystem-based Adaptation cases through literature reviews, interviews, and reports.

Human and Environmental Linkage Programme, Programme Assistant (Sichuan, China) July 2014-June 2015
- Facilitated and assisted in conducting two projects: “Post-earthquake development and conservation in Ya’an, Sichuan, China” and “Mitigate wildlife-human conflict in Wolong Nature Reserve, Sichuan, China”.
- Assisted in designing, preparing and conducting workshops on community-simulated game towards university students, the public and worldwide scholars.
- Co-planned and carried out Vulnerability and Capacity Assessment (VCA), Participatory Rural Assessment (PRA) and socio-economic & natural surveys in Southwest mountainous forest area and watershed.
- Followed up with survey recording, data analysis, regularly report and public communication.
- Present the project and awarded as One of the Three Best Speech at 2014 SCCS-Beijing.

National Student Innovation Project, Project Leader (Sichuan, China) November 2012- May 2014
- Led and organized six-member student team to design and conduct research project “Mistletoe, Taxillus nigrans, distribution and dispersal by birds”.
- Honed skills in field observation of trees and birds; data collection and analysis; proposal and report writing.

International Darwin Scholarship Programme, Scholar (Shrewsbury & London, UK) August, 2013
- Selected as one of 20 worldwide scholars attended the 2013 Darwin Scholarship Programme: “Biodiversity Monitoring and Communication”.
- Gained skills in taxonomy, biodiversity monitoring and communication.

Sichuan University Jianhong Ran’s Laboratory, Research Assistant (Sichuan, China) July 2012-July 2013
- Conducted project “Research on giant pandas conservation strategies in response to climate change” for WWF. Followed up with contributing new strategies in final report.
- Monitored and recorded the growth and recovery of bamboo in giant panda habitat and related nature reserves.
- Recorded and analyzed data that across two regions and four years.

SKILLS, ACTIVITIES AND INTERESTS

- **Computer Skills**: Microsoft Office (Word, Excel, PowerPoint), ArcGIS, R, STELLA
- **Teaching Experience**: Sichuan University, Professor Timothy Moermond: Conservation Biology course and Non-violent Communication Workshops (2013-2014)
Julia R. Entwistle

Phone: 609.332.7650  Email: juliaent@umich.edu  Address: 120 N. State St. Ann Arbor, MI 48104

EDUCATION

University of Michigan School for Environment and Sustainability (Ann Arbor, MI)
- Master of Science, Natural Resources and Environment: Environmental Policy and Planning, April 2018

Rutgers University (New Brunswick, NJ)
- Bachelor of Science, Environmental Policy, May 2013
- Bachelor of Arts, Planning and Public Policy, May 2013
- GPA: 3.7, High Honors

EXPERIENCE

University of Michigan School for Environment and Sustainability
Research Assistant (Ann Arbor, MI) September 2016 – Present
- Editing grant proposals for research group in human dimensions of environmental change
- Reviewing literature for addition to academic papers to be published

Growing Hope
AmeriCorps VISTA (Ypsilanti, MI) February 2015-February 2016
- Planned and lead garden-based nutrition education and cooking programs for youth
- Developed policies and procedures for an onsite field trip program, coordinated and lead field trips for over 200 youth, and completed monitoring, evaluation, and reporting of the program
- Designed and implemented educational demonstration garden spaces
- Recruited and managed a volunteer base of over 150 active volunteers through social media and community partnerships
- Managed a database of volunteer and donor information, generated reports as needed

Peace Corps
Volunteer (Liberia, West Africa) June 2013-October 2014
- Taught mathematics to over 80 students in a public high school
- Evaluated existing student knowledge and developed appropriate curriculums for three grade levels
- Collaborated on various projects with local educational, agricultural, and women’s groups
- Facilitated the organization of a summer school program, including grant writing, evaluation, and reporting

Food & Water Watch
Community Organizing and Advocacy Intern (New Brunswick, NJ) January 2013-May 2013
- Organized volunteer recruitment and coalition building efforts
- Coordinated campaign events and media outreach

SKILLS, ACTIVITIES AND INTERESTS

- Computer Skills: Microsoft Office (Word, Excel, PowerPoint)
- Statistical Analysis: Excel, R/studio
- Academic Projects:
  SEAS Master’s Project (2017) Impact Evaluation of Environmental Restoration Programs in North Shoa, Ethiopia
NATHAN CHESTERMAN
(248) 497-0615, nchest@umich.edu

EDUCATION
University of Michigan School of Natural Resources and Environment (Ann Arbor, MI)

- **Master of Science**, Conservation Ecology, 2016- 2018 (GPA: 3.84)
- **Master's Project**: Impact Evaluation of Rural Environmental Rehabilitation Projects in Northern Shewa, Ethiopia

University of Michigan (Ann Arbor, MI)

- **Bachelor of Science**, 2010 - 2014 (GPA: 3.74)
- **Concentrations**: Biopsychology, Cognition and Neuroscience (with Honors); Evolutionary Anthropology

EXPERIENCE
Sustainability Without Borders, Executive Assistant (Ann Arbor, MI) | October 2016 – Present

- Provide operational support to Sustainability Without Borders, a U-M student organization that builds ethical partnerships based on mutual growth and learning with NGOs and communities around the world
- Projects: developing pre-travel protocols, post-trip report templates, and evaluation plans for project teams
- Arranged logistics for a week-long 9-person trip and 50-participant stakeholder workshop in Monrovia, Liberia


- Facilitated e-learning modules in a Health Systems Management course for over 800 participants
- Provided logistical support for an on-site course on Health Systems Management with over 70 participants
- Managed communications with 75 stakeholders for a consultation on ways to increase use of efficient, clean cooking and heating in developing countries

Ngogo Chimpanzee Project, Research Assistant (Kibale National Park, Uganda) | August 2014 – June 2015

- Tracked a 200-member wild chimpanzee community through tropical rainforest for 11 hours a day, six days a week
- Photographed a cohort of 18 adolescent males to analyze growth patterns and collected urine for hormone analysis, recorded GPS points to map urine collection sites
- Assisted in developing aspects of study design and data analysis protocol

EcoBurrito, Project Manager (Bigodi Village, Uganda) | October 2014 – June 2015

- Assisted in concept-building and business plan creation for a conservation-oriented restaurant in rural Uganda
- Created 10 recipes, trained chef in kitchen hygiene and food preparation, and priced out burrito production
- Developed systems to track inventory and sales that accounted for staff's lack of access to technology


- Transported 10-20 informal educational activities to local schools and libraries on a weekly basis for outreach education events
- Trained up to 20 volunteers on teaching activities at weekly outreach event for up to 200 elementary school-aged children, and facilitated activities for 10-15 students at a time

Camp Tel Yehudah, Unit Supervisor (Barryville, NY) | June 2013 – August 2013

- Trained and supervised two 10-member staff groups in facilitating camp programming for 50 14-year-old campers
- Designed, and supervised writing and implementation of two experiential education curricula about Jewish identity
- Fostered strong team dynamic, held daily staff meetings, and individually mentored counselors through the summer
- Coordinated logistics for two camping trips and day trips to New York and Philadelphia

SKILLS, ACTIVITIES AND INTERESTS

- **Technological Skills**: ArcGIS, ERDAS IMAGINE, GPS Data Collection, Microsoft Office (Word, Excel, PowerPoint), Adobe Illustrator and Lightroom, familiarity with DSLR photography
- **Volunteer Work**: Coordinated fundraising campaign to build classrooms at Kyakagunga Primary School in rural Uganda, raised $30,000 total; staffed week-long Alternative Winter Break for high schoolers in New Orleans, LA
- **Travel Experience**: Extensive travel in East and Southern Africa, Western Europe, Israel and West Bank, and Sinai Peninsula
- **Photography Enthusiast**: Photos published in National Geographic Young Voices, Michigan Today, Detroit Jewish News
- **Languages**: Hebrew (Conversational fluency, limited working proficiency)
EDUCATION

University of Michigan, Ann Arbor, Michigan
- Ph.D. Mechanical Engineering  
  Research: Carbon dioxide recycling and utilization in the U.S. power, industry, and transportation sector (tentative)  
- M.S.E. Mechanical Engineering  
  Research: Least-cost carbon mitigation strategies for power and transportation sectors with direct air capture  
  Courses: Advanced Energy Solutions, Design Optimization, Internal Combustion Engines, Sustainable Design  
- M.S. Natural Resources and Environment  
  Thesis: Residential energy efficiency strategies and policies with ground-source heat pumps  
  Courses: Sustainable Energy Systems, Environmental Systems Analysis, Strategic Planning, and Economics

University of California, Berkeley, California
- B.A. Physics | B.A. Astrophysics  
  Courses: Advanced Mechanics, Thermodynamics, Advanced Electronics, and Physics and Astronomy Laboratories

RESEARCH EXPERIENCE

Independent Research, Ann Arbor, Michigan  
Research Assistant  
- Analyzing the feasibility and merits of carbon removal strategy with DAC on power and transportation sector  
- Quantifying the real cost and performance of DAC given existing energy infrastructure

Center for Sustainable Systems, Ann Arbor, Michigan  
Research Assistant  
- Conducted LCA on residential geothermal heat pump and identified key implementation barriers  
- Designed an environmental and economic model based on two large national databases

UCLA Dark Matter Astrophysics Group, Los Angeles, California  
Research Assistant  
- Participated in R&D of a novel photon detectors and co-supervised three students on summer lab projects  
- Co-authored a journal publication and co-supervised three students on summer lab projects

TEACHING EXPERIENCE

ME 589: Sustainable Design for Technological Systems Class, Ann Arbor, Michigan  
Graduate Student Instructor  
- Co-supervised 16 sustainable design projects in an engineering course of 66 students  
- Helped develop LCA models to assess energy, environmental, social, and economic performance of products

WORK EXPERIENCE

Robert Bosch GmbH, Farmington Hills, Michigan  
Bosch Energy Research Network (BERN) Intern  
- Studying a future powertrain mix for an OEM through fleet modeling, emissions simulation, and market analysis

Center for Carbon Removal, Oakland, California  
Research Intern  
- Developed a policy proposal for federal agencies and blog posts on direct air capture (DAC) technology  
- Conducted industry-wide interviews and surveys and devised near-term RD&D pathway for DAC

Korea Trade-Investment Promotion Agency, Troy, Michigan  
Assistant Manager  
- Consulted business strategy and facilitated key stakeholder meetings for seven clients in auto industry  
- Led market and technology analysis as well as stakeholder engagement. Managed project timeline and budget

LEADERSHIP

University of Michigan, Ann Arbor, Michigan  
Rackham Graduate Student Government, Elections Director & Division II Representative  
- Leading an Elections Committee as a director while representing graduate students in a STEM field  
Sustainability Without Borders, Gasifier R&D Lead  
- Spearheading a gasifier R&D for use in developing countries
Team Leader / Campus Coordinator

- Led four projects on energy, resources, and climate change from strategic planning to execution
- Recruited and trained over ten volunteer leaders. Facilitated outreach events and stakeholder meetings

PUBLICATIONS

- S.D. Supekar, T. Lim, S.J. Skerlos, “On integrating direct air capture plants into the electric grid: costs, emissions, and timelines.” (in preparation)

PRESENTATIONS

- “Geothermal Heat Pump Potentials in the U.S. Residential Houses.” *School of Natural Resources and Environment Capstone Conference, University of Michigan, Ann Arbor, MI.* April 10-11, 2014
- “Geothermal for Homes.” *External Advisory Board Meeting, University of Michigan, Ann Arbor, MI.* March 31, 2014