USAID
FROM THE AMERICAN PEOPLE

Regeneron International Science and Engineering Fair **(ISEF)**

USAID Science for Development Award

2023 Winners

Global Health

Agriculture & Food Security

Climate & Environmental Protection

Working in Crisis & Conflict

18 young scientists

$40,000 in awards

Brilliant **solutions** for development

USA

Brazil

Haiti

India

Thailand

Vietnam

American Samoa

Letter from the Director

Emmanuella Delva, Ph.D

Acting Director, Research Division
Deputy Director for Research Policy, Research Division
Innovation, Technology, and Research (ITR) Hub
Bureau for Development, Democracy, & Innovation (DDI)

Congratulations to these 18 exceptional students who have received the USAID Science for Development Award at the Regeneron International Science and Engineering Fair (ISEF) 2023! As budding scientists fueled by their passion for exploring new ideas, they hold a vital key to shaping the future of global development.

USAID has served as a Special Award Organization at ISEF for nine years and awarded more than $300,000 to over 100 students from 14 countries. These young scientists' outstanding research and innovative ideas are the start of solutions to many development challenges. In a world where global health, agriculture and food security, climate and environmental protection, and working in crisis and conflict demand our attention, research fosters self-resiliency worldwide.

Student projects varied from detecting disease and monitoring air quality using machine learning, to creating sustainable and eco-friendly pest control, to using a new robot model to assist with search and rescue in prominent landslide areas, and more. All of these ideas contribute to our mission of using innovations to help humanity. Within the Research Division of USAID's Innovation, Technology, and Research Hub, we support scientists whose projects and research are testing innovative ideas that can improve our world; our 2023 winners exemplify the caliber of research and ideas required to do so. We are honored to participate in the fantastic opportunity that is ISEF. Our Science for Development Award Winners inspire us and bring us hope for the future of research and development.

We look forward to the bright future ahead for you and your projects. Continue to share your knowledge and expand your horizons; it is extremely valuable and will someday change our world.

Emmanuella Delva

2023 USAID Science for Development Award ISEF Winners

Global Health

1st Place:

Alex Wang, United States of America
Spatially Multiplexed Gold Leaf Electrodes for Affordable Pathogenic Detection

2nd Place:

Ishan Choudhary and Aditya Kumar Jha, India
HepaEase Development of Risk Assessment Tool and xLFIA Validating Potential Urinary Biomarkers for Early Detection of NAFLD

3rd Place:

Lakshika Nanda Kumar Reddy, United States of America
Detecting Cataracts From Front-View Retinal Images Using Machine Learning

Agriculture and Food Security

1st Place:

Prisha Bhat, United States of America
Agro-Rhizoremediation: Rhizoremediation with Agro-transformed *Oryza sativa* to Facilitate Degradation of Arsenic in-Situ (Year III)

2nd Place:

Sunyapat Akkarajeerawat and Thanatkorn Chauvanasmith, Thailand
A Sustainable Approach to Control the Destructive Red Palm Weevil Pests

3rd Place:

Marc Lesly Morency, Louis Marie Olivier Rolles, and Witchy Rosemane, Haiti
Affordable and Readily Accessible Solar Dehydrator

2023 USAID Science for Development Award ISEF Winners

Climate and Environmental Protection

1st Place:

Lauanda Vitoriano Lima and Kalyne Vitoria Ferreira Falcao Pereira, Brazil

Low Cost Ecological Filter for Water Treatment, Made on the Basis of Activated Carbon from Black Jurema Biomass (*Mimosa hostilis*)

2nd Place:

Amelie Chen, American Samoa

Antipodal Algae: Energy Solutions for a Tropical Island

3rd Place:

Eliana Kai Juarez, United States of America

Addressing Disparities in Air Quality Monitoring: Using Machine Learning and Remote Sensing to Estimate the Distribution of PM2.5 in Mexico

Working in Crisis and Conflict

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Sruti Peddi, United States of America

FloodCast: Real-Time Flood Mapping and Prediction in Southeast Asia Using Remote Sensing Data

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Lucas Hadlich Camargo Sampaio, Brazil

Development of a Low-Cost Network System to Monitor Landslides in Urban Hills

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Minh Duc Minh Duc and Le Trung Kien Nguyen, Vietnam

Quadruped Robot Model Assisting with Searching and Rescuing People in Landslide-Stricken Areas

Global Health

Global Health

1st Place

Alex Wang

United States of America

Spatially Multiplexed Gold Leaf Electrodes for Affordable Pathogenic Detection

Abstract: Socioeconomically disadvantaged individuals suffer disproportionately from vaccine preventable diseases. This is due, at least in part, to a lack of accessible screening tools for such illnesses. By creating an affordable, specific, and sensitive point-of-care diagnostic for tuberculosis, access to detection methods for a broader subset of the global population can occur. Herein, an inexpensive, easy-to-produce, multiplexed electrochemical biosensor for tuberculosis detection is reported.

This diagnostic functions by integrating spatially-multiplexed gold leaf electrodes with loop-mediated isothermal amplification (LAMP) and CRISPR-Cas12a. Resulting changes in DNA on the gold leaf surface translate to detectable changes in signal that enable identification of tuberculosis genetic material and thus signal change. This experimental work was coupled with computational simulations in MATLAB to optimize experimental parameters. This study represents an advancement in affordable POC diagnostics for vaccine-preventable diseases.

Global Health

2nd Place

Ishan Choudhary and Aditya Kumar Jha

India

HepaEase - Development of Risk Assessment Tool and xLFIA Validating Potential Urinary Biomarkers for Early Detection of NAFLD

Abstract: Non-alcoholic fatty liver disease (NAFLD) has emerged as a significant cause of chronic liver disease globally, affecting 25 percent of the population. The condition is characterized by an excessive accumulation of fat in the liver of individuals who consume little or no alcohol. As the disease progresses to its advanced stages, the risk of hepatocellular carcinoma (HCC) increases sevenfold. Due to the lack of early detection methods, most cases are diagnosed only at the later stages when the condition becomes incurable.

In this study, we have identified the potential urinary biomarkers of NAFLD via meta-analysis and based on it, developed a sensitive and reliable at-home test for the precise detection of markers in individuals with NAFLD using a multiplexed lateral flow immunoassay. The test is based on the principle of the binding of detection antibodies with their respective target markers, which inhibits a red ruby color. By utilizing two test lines in the strip, we can target multiple analytes, increasing the chances of detection. The intensity of the test line after the binding of reagents depends on the quantity of the metabolite in urine, providing specific results. The developed kit can help in minimizing the odds of fibrosis, cirrhosis, and liver cancer by enabling individuals to conduct the test at intervals within the comfort of their homes. We have also developed an ensemble learning-based risk assessment toolkit that can help individuals determine their quantitative risk of developing NAFLD and encourage them to use our developed test strip. Our work thereby improves the overall prognosis of the disease.

Global Health

3rd Place

Lakshika Nanda Kumar Reddy

United States of America

Detecting Cataracts From Front-View Retinal Images Using Machine Learning

Abstract: Cataracts, which are the clouding of the crystalline lens, are a progressive disease, and their early detection is critical for preventing blindness. There are some manual techniques to detect a cataract, like an ophthalmologist who diagnoses a cataract by using a slit lamp exam. However, many countries lack access to medical facilities, where diseases such as cataracts are a major health issue.

The application, in the form of a mobile app, uses on-device machine learning to detect cataracts from a simple smartphone camera. The model was trained using front-view retinal images of cataract eyes or healthy eyes. During the initial model training, it was found that the six convolutional layers had low validation and training accuracies, indicating overfitting of the data. To resolve this issue, the convolutional layers were reduced, and more max pooling layers were added. The app allows the user to select an image from their camera roll or take a new image from the smartphone camera and import it into the app. The user can then run the model and receive the result of the model's prediction on their front-view retinal images.

The research illustrated that on-device machine learning can be successfully implemented to classify retinal images in order to diagnose cataracts on a smartphone app. Furthermore, the app has potential to help low-income areas without the necessary eye-care facilities to diagnose cataracts in a cost-effective and time-saving way.

Agriculture & Food Security

Agriculture and Food Security

1st Place

Prisha Bhat

United States of America

Agro-Rhizoremediation: Rhizoremediation with Agro-transformed Oryza sativa *to Facilitate Degradation of Arsenic in-Situ (Year III)*

Abstract: Arsenic accumulation in rice is becoming increasingly problematic, threatening the health of over 150 million people globally. This project aims to use rhizoremediation with rice plants transformed with arsenic-resistant genes to facilitate the self-detoxification of arsenic. Raw sequences of 16s rRNA from 82 soil samples obtained from the National Center for Biotechnology Information were processed through Qiime2 to examine bacterial taxonomy in arsenic-contaminated and uncontaminated soil rhizospheres. Pseudomonas and Burkholderia genera constituted over 63 percent of the microbial community in contaminated rhizospheres. Rice cotyledons infected with transformed (acr3 and arsC arsenic-resistance genes) Agrobacterium tumefaciens were cultivated in plant tissue culture media to develop transgenic rice plants. The transformed rice plants were then grown in soil inoculated with P. putida contaminated with 25 ppm arsenic. Arsenic content in the soil, stems, and leaves were measured at various stages of plant growth. After four weeks, there was a 60 percent decline in soil arsenic from baseline. Arsenic content in transgenic stems was less than one ppm, compared to six ppm in non-transgenic plants, and was undetectable in the leaves in transgenic plants. Statistical significance was confirmed using three T-Tests. Spectrophotometric chlorophyll content analysis demonstrated that genetic transformation and arsenic decontamination did not negatively affect plant health. Results supported that genetically modified rice plants were effective in arsenic self-detoxification. Therefore, rhizoremediation using agro-transformed rice plants is a promising method for decontaminating polluted soil and lowering arsenic accumulation in rice grains.

Agriculture and Food Security

2nd Place

Sunyapat Akkarajeerawat and Thanatkorn Chauvanasmith

Thailand

A Sustainable Approach to Control the Destructive Red Palm Weevil Pests

Abstract: Red palm weevil (a beetle, Rhynchophorus ferrugineus) is a promising source of low-cost, high-quality protein commonly cultivated in Southeast Asia. We found a correlation in the increased weevil cultivation and the damage to palm plants, due to the uncontrolled growth rate of the weevils leading to economic loss in palm industries.

This study mainly aims to develop a sustainable, organic, and cost-effective approach to control the weevil's metamorphosis rate to reduce the plant invasion by insects. We also aim to enhance the nutritional value of insect powder to address the global food shortage issue. Results show that feeding weevils with food containing specific herbs resulted in a significant reduction in the metamorphosis rate at pupation stage. Kra-jeab (a roselle Hibiscus sabdariffa) and kra-pao (a holy basil Ocimum tenuiflorum) decreased metamorphosis rate by 76.7 percent and 50.0 percent, respectively, with a higher reduction rate of 86.7 percent when the two herbs were combined. Interestingly, metamorphosis could not at all occur when using coconut coir to replace coconut fiber as insect's nest bedding. Moreover, supplementing the optimized feed with soybean meals for four weeks led to 6.93 percent increase in protein. Insect powder was made, then protein and food parameters were analyzed.

In conclusion, this work demonstrates the potential application of plant-based feed to slow down weevils' metamorphosis rate to control their destructive impact on palm industries, thus likely to resolve issues between palm and insect farmers. The work also extends to making insect powder having high protein content to increase insect farmers' income.

3rd Place

Marc Lesly Morency, Louis Marie Olivier Rolles and Witchy Rosemane

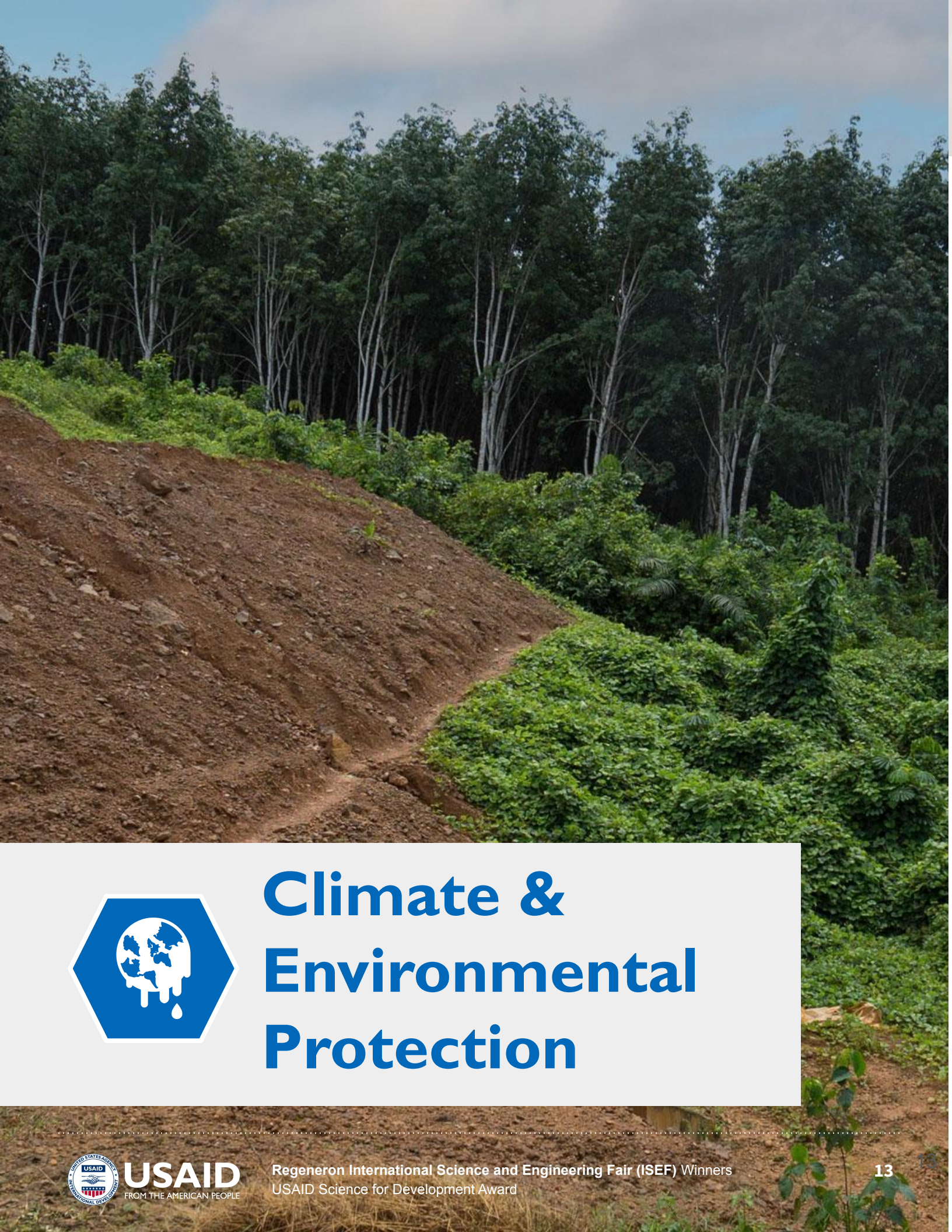
Haiti

Affordable and Readily Accessible Solar Dehydrator

Abstract: For over a year, the majority of households in Haiti have been without power. This is the cause of large amounts of food waste due to a lack of cheap and accessible methods of food conservation. In response to this problem, we propose a modified solar food dehydrator made up of cheap, everyday materials.

Our prototype is composed of two parts: a panel to capture solar energy and a box that holds the food. Sun rays get into the panel box through a clear glass pane, where they get absorbed by a black metal sheet. Air comes through the bottom and is heated by radiation and convection. The heated air then travels through an insulated tube into an insulated box containing the food. The air dries the food, and the moisture released is evacuated through an exhaust pipe on top of the insulated box. The insulation prevents heat loss through walls of the box, thus improving efficiency. Both boxes are made of wood, and the insulated pipe is made of PVC lined with aluminum foil. The panel was fabricated in-house using a sheet of plywood, a 1 by 6 piece of wood, black paint, and a metal sheet that serves as a capacitor. This means it regulates the box temperature if there is temporary loss of sunlight. Our device successfully reached a temperature of 55 degrees Celsius, which is the perfect temperature for dehydration. We found that our device was capable of releasing heat 30 minutes after it was removed from the sun.

We plan to improve our design by doubling the glass pane to introduce a layer of air in between that would allow for extra insulation. We will also be adding a temperature control system into our dehydrator because different foods dehydrate at different temperatures. Furthermore, we think a smaller form factor can improve portability and affordability.



Climate & Environmental Protection

1st Place

Lauanda Vitoriano Lima and Kalyne Vitoria Ferreira Falcao Pereira

Brazil

*Low Cost Ecological Filter for Water Treatment, Made on the Basis of Activated Carbon from Black Jurema Biomass (*Mimosa hostilis*)*

Abstract: Bearing in mind the scarcity of water in the Northeast region of Brazil and throughout the whole country, scientific initiatives are needed in order to seek ways to provide clean water to the population but, above all, to needy families. In the present work, wastewater was treated with the help of an ecological filter composed of activated carbon made from the selected and studied biomasses. In the city of Pedra Branca - CE, which is at the epicenter of the caatinga biome, there is an abundance of black jurema (*Mimosa hostilis*) vegetation, a plant constantly discarded improperly.

The study was carried out with different biomasses, and based on the analyses, the use of black jurema proved itself to be advantageous. After the carbonization of the source material, the activated carbon was crushed, becoming granular. To assess the efficiency of the activated carbon, the pH test was performed. This test resulted in a value of seven, therefore proving it to be a neutral charcoal, ideal for water treatment. In order to bring a better application for the prototype, the porosity activation and the adsorption test were carried out, through qualitative and quantitative means, to analyze the retention capacity of the waste. After this process, the assembly of the filter began, using a PET bottle and consisting of layers, the first having a siliconized polymer, the second having granular charcoal, the third having sand, and the fourth having stones. From this point on, the water treatment was carried out, and its efficiency was verified through physical-chemical and microscopic analysis of the raw and of the treated water. The work concluded with the elaboration and application of the project, a viable alternative for the reuse of contaminated water.

Climate and Environmental Protection

2nd Place

Amelie Chen

American Samoa

Antipodal Algae: Energy Solutions for a Tropical Island

Abstract: As the emission of carbon dioxide into our atmosphere continues to contribute to climate change, the search for a cleaner energy source prevails. Using algae as a biofuel can replace our use of diesel fuel in American Samoa because algae is both naturally abundant and grows at a fast rate. Algal biofuel is also a very promising fossil fuel replacement due to algae's high levels of lipids which can be extracted efficiently without the use of dangerous chemicals. American Samoa has the ideal climate to grow and harvest algae as biofuel.

Applying experimental methods that I learned at a biotechnology course at the University of California Berkeley, I was able to extract algal lipids and convert them into biofuel using the local resources found on our island. After harvesting and growing three of the most abundant algal samples from our island, I measured the mass of each algae species and observed and analyzed my data. In my results, I found that ocean algae reproduces faster than freshwater algae. To test which species contains the most lipids, I combined the lipids with potassium iodide made from coconut ash and found that filamentous algae produces the most algal biofuel.

In this project, I was able to convert algae into algal biofuel using local resources and discovered what species could potentially replace our fuel source in American Samoa.

3rd Place

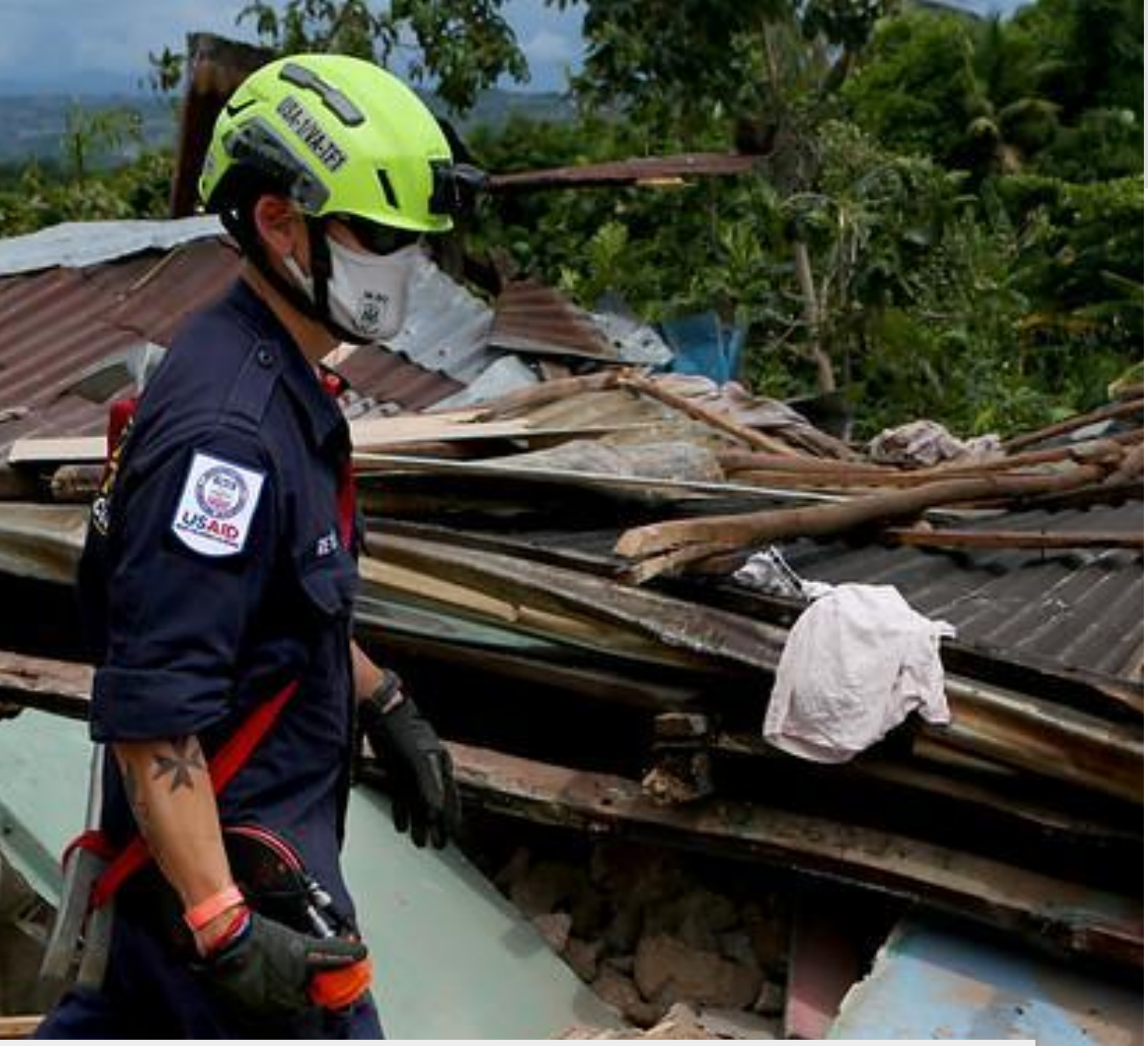
Eliana Kai Juarez

United States of America

Addressing Disparities in Air Quality Monitoring: Using Machine Learning and Remote Sensing to Estimate the Distribution of PM2.5 in Mexico

Abstract: Air pollution is the single greatest environmental health threat, according to the WHO, and disproportionately impacts developing nations, which suffer 90 percent of the five million premature deaths globally per year due to air pollution. This is in part due to the "outsourcing" of pollution to countries with lesser air quality regulation and research on regional air pollution monitoring when compared to the United States, Europe, and East Asia, as most international treaties hold countries responsible only for emissions produced within their borders. Air pollution, however, is a global matter, and must be addressed with research at the regional level.

To combat the disparity in the geographic focus of research, this project details the process of creating the first continuous map of fine particulate matter (PM2.5), the most dangerous pollutant, over Mexico, using data sources and methods that may be easily applied to other regions of the world as a baseline for more specialized regional studies. A nationwide model to estimate PM2.5 in regions with few ground stations is developed using satellite data, historical ground pollutant monitoring, and land use variables. This is compared to NASA's MERRA-2 hourly surface particulate matter estimates for 2018. To provide continuous estimates of air pollution in regions without monitoring stations, a machine-learning model that incorporates historical ground monitoring, meteorological parameters, and physical model simulations is developed and tested, with cross-validated R scores up to 0.88—the first of its kind covering all of Mexico.



Working in Crisis & Conflict

Working in Crisis and Conflict

1st Place

Sruti Peddi

United States of America

FloodCast: Real-Time Flood Mapping and Prediction in Southeast Asia Using Remote Sensing Data

Abstract: Floods kill 6,000 people annually and are especially dangerous for the region of Southeast Asia (SEA), where 1.24 billion people are at risk of flooding. Flood mapping often uses ground measures, but they only measure water height, are spatially limited, and can be expensive to maintain—which isn't feasible for Southeast Asia.

High resolution synthetic-aperture radar (SAR) imagery offers continuous observation of the Earth's surface and is ideal for flood mapping. Neural network mathematically determines flooding pixel by pixel. My most successful model had a >0.80 IoU and thus successfully captured polarized SAR data, allowing for real-time flood mapping of SEA. In addition to topological and hydrological data, this project establishes a strong correlation between flood risk and soil moisture. A machine learning model trained upon these factors was first validated in Iowa due to high quality hydrological modeling and frequent flooding. Due to lack of tuning and subnational ground truth data, this model was applied to SEA.

FloodCast proved to have less than 5 percent of error compared to actual flooding events in SEA and was more than 90 percent accurate in real-time flood prediction, surpassing the gold standard. The project's versatility and simplicity proves that anyone with a computer can map and predict floods, an invaluable tool.

2nd Place

Lucas Hadlich Camargo Sampaio

Brazil

Development of a Low-Cost Network System to Monitor Landslides in Urban Hills

Abstract: In the Brazilian perspective, landslides became very common in risk regions where communities lacking public services are found. A Brazilian community's environment is favorable for disaster occurrences. Because of the lack of governmental attention to social, natural, and economic troubles, people have no choice, but to degrade the soil in order to survive, even though this action leads to their own death. Moreover, the global weather change announced by the Intergovernmental Panel of Climate Change (IPCC) worsens the situation, since the rains, the main trigger factor, now are more violent, thus resulting in more catastrophic disasters.

In that regard, a low-cost alternative to constantly monitor specifical landslides trigger aspects is vital to assure people's well-being. Parameters are strictly related to landslide occurrence and they all are monitored by specific sensors. Categories include rain intensity, soil humidity, and geological vibrations. Beyond the sensors, there is our original optical system, which correlates light signal intensity in an optical fiber with the avalanche eminence. All the information is gathered and utilized by an online platform to construct graphics showing real-time data in a public channel for both civilians and rescue authorities. Therefore, they are capable of ensuring their safety in high geological risk sites.

3rd Place

Minh Duc Le and Le Trung Kien Nguyen

Vietnam

Quadruped Robot Model Assisting with Searching and Rescuing People in Landslide-Stricken Areas

Abstract: In Vietnam, landslides occur frequently and cause great damage to traffic infrastructures and human lives. Follow-up search and rescue campaigns risk the lives of rescue personnel and civilians. To tackle this problem, we raised a solution of creating a quadruped robot that is capable of moving in landslide-stricken areas and integrated functionalities that assist rescue operations.

We researched nature's characteristics—a golden retriever's legs and stand height ratios, a platypus' feet and a Arapaima Gigas fish's scales—for the production of our own quadruped model and the unique webbed feet design. We calculated the oscillation of the quadruped robot's center of gravity during movements and torque requirements for servo selection. Later, we integrated the Inverse Kinematics problem, together with the end-effector trajectory problem for motion programming. During experimentation while the robot stood on mud with 50 percent water composition, pressure applied on each webbed foot decreased by 25 times compared to traditional rounded foot design. Additionally, scales in the feet's web allow them to not be pierced by small sharp rocks or debris.

The novel feet design together with the spring suspension yielded greater efficiency in all 8 gaits of movements, climbing 10-20 degrees of hard surface slopes and walking on soft mattresses. The robot can provide feedback on soil hardness data for determination of the robot's feet placement. Live video and GPS data can be effectively transmitted from 10-30 meters. We hope that this project can contribute to safer and more efficient landslide rescue operations not only in Vietnam but also in the world.