

Regeneron International Science and Engineering Fair (ISEF)

USAID Science for Development Award
2022 Winners



Global Health



Agriculture and Food Security



Climate and Environmental Protection



Working in Crisis and Conflict

17 Young Scientists
\$40,000 in awards



USA



Brazil



India



Thailand



Vietnam



Zimbabwe



USAID
FROM THE AMERICAN PEOPLE

Letter from the Director

Ticora V. Jones. Ph.D



USAID Chief Scientist

Acting Director for the Innovation, Technology, and Research (ITR) Hub,
and Managing Director for Research in the ITR Hub

Bureau for Development, Democracy, & Innovation (DDI)

Congratulations to these 17 hardworking students whose projects received the USAID Science for Development Award at the Regeneron International Science and Engineering Fair (ISEF) 2022! As young scientists committed to researching and testing new ideas and approaches, these award winners will help address the world's most pressing challenges.

Since 2014, USAID has awarded \$300,000 in awards to more than 100 students from 13 countries. Research transforms lives. It helps us understand complex problems and create solutions across cultures, regions, and sectors. Research-based tools and innovations improve the way we plan for and respond to disasters, design our health systems, build resilience, boost agricultural productivity, and increase our understanding of environmental changes. We are proud to support these innovative thinkers and are encouraged by their pursuit of knowledge to improve our world.

USAID is honored to serve as a Special Award Organization at ISEF and encourage young intellectual ability to use science to solve real world challenges. This year, we were thrilled to discover promising research and innovations from today's brightest students that prevent, detect, and treat disease, improve crop resilience, decrease pollution, reduce human-animal conflict, and predict and respond to disasters. A significant portion of what we do involves taking smart risks and forming partnerships to test creative new ideas. Students - including our 2022 winners! - will always play an integral role in this approach.

Thank you for inspiring us. We look forward to seeing what's in store for you, your schools, and your projects. Keep learning, keep testing, and keep sharing!

Best wishes,

A handwritten signature in cursive script that reads "Ticora V. Jones".



2022 USAID Science for Development Award ISEF Winners



Global Health

1st Place:

Kulpatch Chananam, Kunat Khongtong, and Pakitta Kriangasame, Thailand

Sawasdee-AMP: Highly Efficient, Portable and Low-Cost Point of Care Test Kit for Future Emerging RNA/DNA Diseases Diagnosis

2nd Place:

João Pedro Silvestre Armani, Brazil

Application of Agroindustrial Residues in the Combat of the Arbovirus-Vector Mosquito (*Aedes aegypti*), Phase II

3rd Place:

Maggie Zhang, Kansas

The Effect of Polymer Coating on Taste-Masking Ability of AZT (HIV Drug) for Pediatric Oral Delivery



Agriculture and Food Security

1st Place:

Mehdi Mohsen Achour, Oklahoma

Orange is the New Green; From Waste to Water Absorbent BioPolymer: How Can Orange Peels Help Plants Resist Drought?

2nd Place:

Nathan Elias, Texas

A Novel Method for Automated Identification and Prediction of Invasive Species Growth Using Deep Learning

3rd Place:

Ava Zhang, New York

Soilization of Sand Indicated by Photosynthetic Rate, Water Retention Rate, and Health of Plants

2022 USAID Science for Development Award ISEF Winners



Climate and Environmental Protection

1st Place:

Nyaradzo Nicole Mutiti, Omar Chinyanga, and Stanley Madziyire, Zimbabwe

Development of a Low-Cost Highly Efficient Filter for Heavy Metal and Organic Contaminant Removal

2nd Place:

Chinmayi Ramasubramanian, India

Averting Human-Elephant Conflict Using Machine Learning on Elephant Vocalizations

3rd Place:

Jacqueline Prawira, California

Cyclo.Cloud: Development of Fish Scale Waste-Derived Materials for Adsorbance of Aquatic Pollutants



Working in Crisis and Conflict

1st Place:

Matthew Hansol Jabez Kim, Georgia

Search and Rescue System Using Omni-Orientation Mapping Robots

2nd Place:

Sunny You, Florida

Predicting Future Tropical Cyclone Intensity Using a Convolutional Neural Network

3rd Place:

Phong Tran and Chi My Tran, Vietnam

A Humanitarian Blood Donation Application That Facilitates the Search for Potential Blood Donors and the Smart Management of Blood Storage



Global Health



Regeneron International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award



Global Health

1st Place

**Kulpatch Chananam, Kunat Khongtong,
and Pakitta Kriangasame**



Thailand

*Sawasdee-AMP: Highly Efficient, Portable and Low-Cost Point of Care Test
Kit for Future Emerging RNA/DNA Diseases Diagnosis*

Abstract: Coronavirus, an RNA virus that causes COVID-19, has spread widely around the globe. We know that testing can be an effective way to limit the spread of such viruses and both Polymerase Chain Reaction (PCR) and antigen test kits (ATK) have been widely used. PCR testing is highly reliable but also expensive and requires a laboratory. The ATK are simple and inexpensive but the results can be unreliable. Therefore, there continues to be a need for accurate and portable tests that can serve remote and low-resource settings. The team developed a new, easy-to-read test kit called Sawasdee-AMP that shows 96% accuracy and 10 times higher sensitivity than PCR tests. Combined with a five minute, equipment-free extraction procedure, the portable diagnosis process takes less than one hour from sampling to results, costs about \$2, and is faster than PCR testing. The team tested Sawasdee-AMP with various target DNA and RNA viruses, bacteria, and parasites representing human, animal, and plant infections, and demonstrated the test as a viable point-of-care diagnostic.



Global Health

2nd Place

João Pedro Silvestre Armani



Brazil

Application of Agroindustrial Residues in the Combat of the Arbovirus-Vector Mosquito (Aedes aegypti), Phase II

Abstract: *Aedes aegypti* is the vector of dengue, chikungunya, yellow fever and zika, which are some of the world's biggest problems. The only effective way to combat them is to eradicate their transmitter, since the current insecticides cause environmental contamination and diseases. Another current problem is the disposal of residues such as coffee and grape peels, and tilapia scales, which contaminate the environment when discarded. Because of this, it was decided to test natural products that could combat the mosquito. This work aims to evaluate the larvicide, pupicide, ovide and lethal effects of agroindustrial residues against *Aedes aegypti*. The production of the insecticide solutions was carried out from alcoholic extracts at 99.8%, which were rotaevaporated and applied at different concentrations, ranging from 25 to 40 mL/L. The bioassays followed, in the majority, the methodology described by the World Health Organization (WHO), with some adaptations. The data obtained were subjected to a two-way analysis of variance and the means were compared by Tukey's Test ($p < 0.05$). Also, a Probit Analysis was performed to determine the lethal concentration values (CL99). The conclusion was that the solutions made from residues have a fast insecticidal effect against *Aedes aegypti* eggs, larvae and pupae. Furthermore, the solutions do not present phytotoxicity, were well accepted by the population and have a long residual effect. This way, not only the number of arboviroses transmitted by the insect is reduced, but also environmental contamination and diseases caused by synthetic insecticides are avoided. Thus, this study presents social, environmental and scientific value.



Global Health

3rd Place

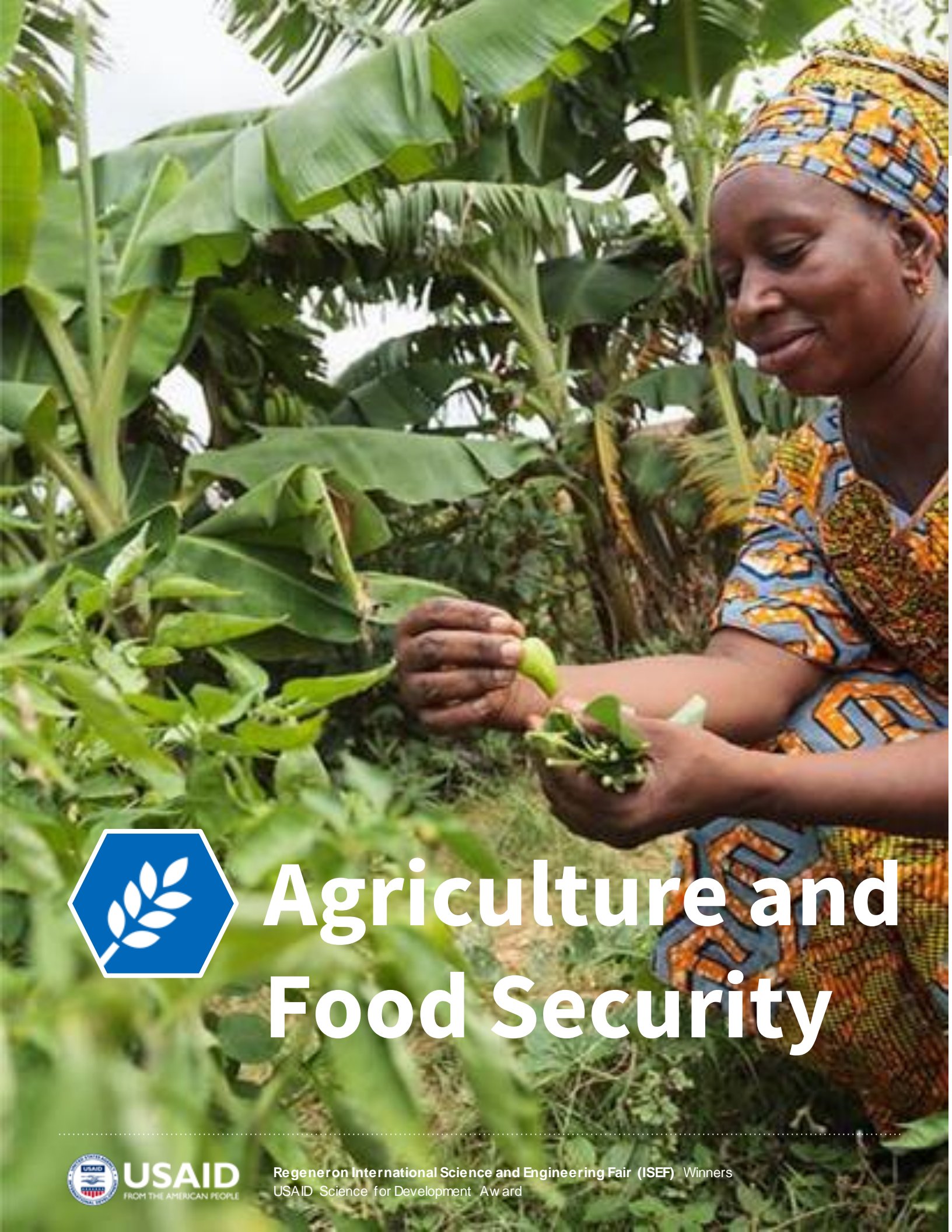
Maggie Zhang



Kansas, USA

The Effect of Polymer Coating on Taste-Masking Ability of AZT (HIV Drug) for Pediatric Oral Delivery

Abstract: Formulating an HIV drug as an oral thin film (OTF) can overcome many drawbacks of the current WHO-approved pediatric HIV antiretroviral therapy regimen used in sub-Saharan Africa. The current regimen uses two liquid HIV medications that are packaged in two large, bulky bottles. These bottles can be difficult to transport and store. Additionally, infants tend to spit up large amounts of liquids which can easily lead to dosing error. Oral thin films offer a more patient-compatible alternative compared to the current regimen. We tested four different ratios of drug:polymer to find which would be most optimal for the formulation of an oral thin film without sacrificing dose. We hypothesized that the 65:35 ratio would be the most optimal as we hypothesized that increasing polymer in the ratio would reduce dissolution of AZT in the mouth. However, after analyzing results, further research is needed to answer the research question as the change in dissolution between ratios could be due to either changing ratios or changing fraction of soluble drug-further research is needed to determine which factor is responsible. More work should be done to confirm what variables are controlling the release of AZT from the spray dried formulation.



Agriculture and Food Security



Regeneron International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award



Agriculture and Food Security

1st Place

Mehdi Mohsen Achour



Oklahoma, USA

*Orange is the New Green; From Waste to Water Absorbent BioPolymer:
How Can Orange Peels Help Plants Resist Drought?*

Abstract: Fresh water is of vital importance to farmers, but nowadays, unpredictable weather patterns and extended drought threaten food producers' access to an adequate supply. One solution in combating drought might be Superabsorbent Polymers (SAPs). Most SAPs are manufactured from acrylic polymers which have no biodegradability and are not environmentally friendly. The purpose of this study is to make a low-cost, sustainable, biodegradable hydrogel from orange peels and avocado skins. My Hypothesis is: If orange peels and avocado skins are mixed and pre-treated using heat and sunlight, then the product would be a tri-dimensional macromolecule that is capable of retaining water in soil because fruit-pectin is rich in polysaccharides which, under certain conditions, can bond with the avocado's phenyl compounds, polymerise and condense into a hydrogel when added to water. In this experiment, an Organic mixture was prepared from pectin and avocado natural oils through the process of emulsion polymerization. Its ability to absorb and retain water in soil was tested, then compared to potassium polyacrylate, and applied to real life situations. The acrylic SAP had a superior absorbency. However, the Organic mixture displayed a better water retention capacity, which promoted seed germination, plant growth, and helped them resist drought throughout a period of 2 weeks. My hypothesis was supported by my results. A cheap, natural water-absorbent was produced using only fruit waste, sunlight, and heat. This method is worth investigating on a larger scale as it has various applications in agriculture, the biomedical field, and the treatment of wastewater.



Agriculture and Food Security

2nd Place

Nathan Elias



Texas, USA

A Novel Method for Automated Identification and Prediction of Invasive Species Growth Using Deep Learning

Abstract: Alien invasive species (AIS) cause habitat destruction, lower crop productivity, climate change, and significant losses in global biodiversity. Global efforts to control rapid expansion of AIS have cost \$1.2 trillion. With current AIS response/detection, 42% of threatened/endangered species continue to be at risk. This project aims to automate the detection and prediction of AIS growth using machine-learning-based classification and geospatial prediction models. 2-Dimensional Convolutional Neural Networks (CNNs) were developed, employing transfer learning architectures, Generative Adversarial Networks, and hyperparameter tuning algorithms. The 2D-CNNs can identify 114 high-impact AIS and native species with 93.52% accuracy. Furthermore, using 152,657,384 3-Dimensional datapoints from AIS scans, 3D-CNNs were developed. Utilizing the Stanford PointNet segmentation architecture to detect invasive genera in aquatic, heat, and ambient conditions at various growth stages, the 3D-CNNs achieved a 97.78% validation accuracy, encompassing over 75 detectable AIS. Additionally, geospatial LSTMs were created, using climatic and AIS clusters/predatory data to accurately predict suitable locations of spread for AIS in the future. A total of 840 geospatial heat projection maps were created with a negligible training loss of 0.0143. The 2D-CNNs and LSTMs were also deployed to a mobile app. Several blinded field studies were conducted to validate the model results, with an average top-5 accuracy of 91%. The creation of state-of-the-art multidimensional classification/prediction models allows expansion into areas like dynamic LIDAR/aerial detection of AIS growth. Overall, this research offers an inexpensive, scalable, and previously unreported solution to the global AIS crisis.





Agriculture and Food Security

3rd Place

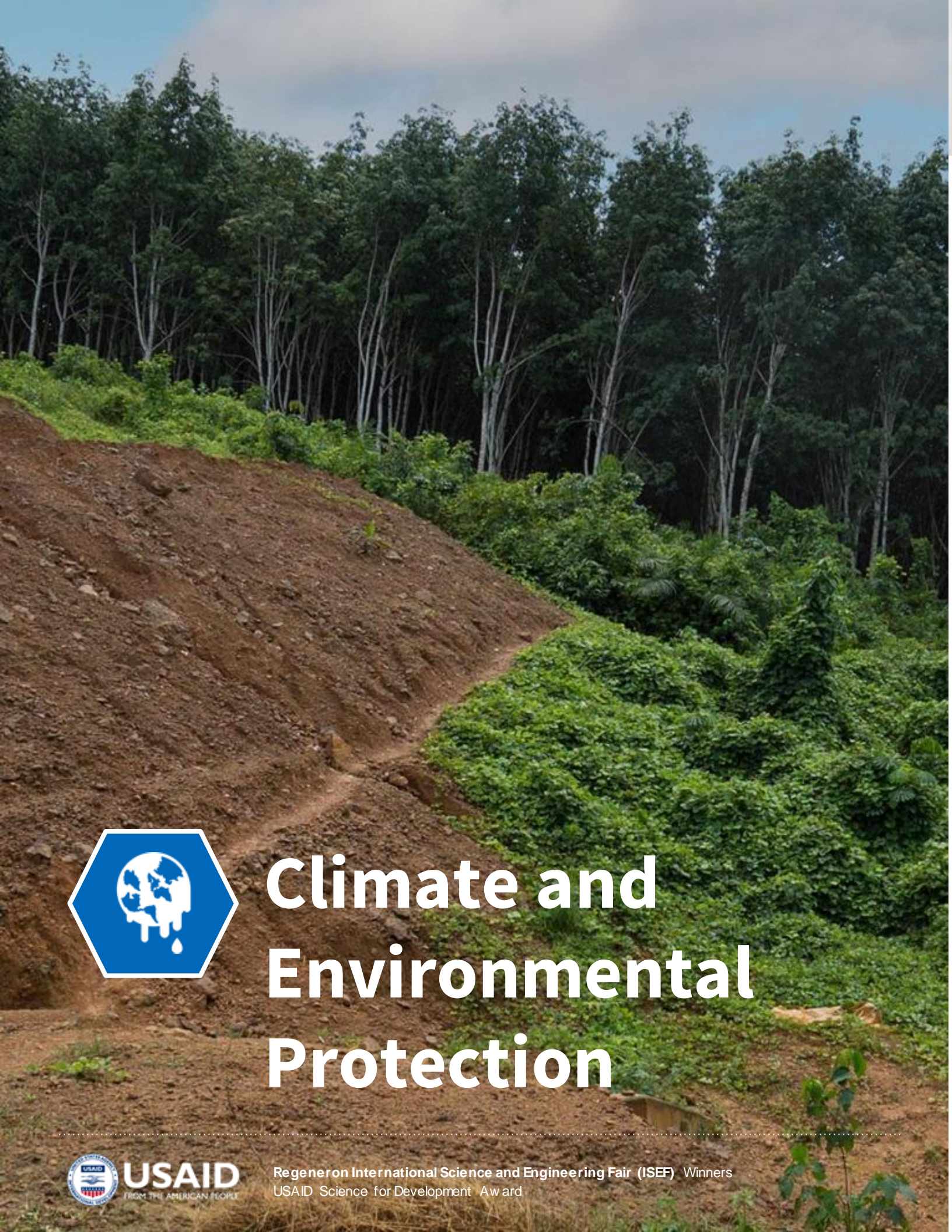
Ava Zhang



New York, USA

Soilization of Sand Indicated by Photosynthetic Rate, Water Retention Rate, and Health of Plants

Abstract: Desertification, which is increasing at an alarming rate, imposes food insecurities for nations with huge desert areas and weakens ecosystems. Many methods, like sand fences, have been developed to combat desertification, but soilization is a relatively new approach aimed at slowing desertification, while providing crop yields. In previous studies, I experimented with 4 additives: Carboxymethylcellulose (CMC), Bentonite, mycorrhizal fungus, and lichen and monitored plant height and visual health during drought conditions to determine the most effective combination. Mycorrhizal fungus consistently showed beneficial plant health, along with the Bentonite-fungus combination. CMC, however, yielded no measurable benefit. My hypothesis in this study is that combinations of Bentonite with either mycorrhizal fungus or lichen impart greater plant health. My experimental approach was to record the height, Dark Green Index (DGCI), viability of harvested beans and apparent health of soybean plants that were planted in sand samples treated with individual and combinations of additives. One set of sand samples was freshly treated while the other was treated in the previous study and re-used. The results indicated that whereas the fresh treatment did have a significant advantage in terms of bean size, possibly due to nutrients added by the commercial Bentonite suspension, the sand treatments that had been treated the year before provided a significant increase in the DGCI, and plant height. This study suggests that the low-cost resources, Bentonite and either lichen or mycorrhizal fungus, could be added to desert land and impart long-lasting soilization needed to improve agriculture, food security, and resist desertification.



Climate and Environmental Protection



Regeneration International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award



Climate and Environmental Protection

1st Place

**Nyaradzo Nicole Mutiti, Omar Chinyanga,
and Stanley Madziyire**



Zimbabwe

Development of a Low-Cost Highly Efficient Filter for Heavy Metal and Organic Contaminant Removal

Abstract: The size and complexity of e-waste is increasing at a much faster rate than the efficiency of our strategies to contain it. Lake Chivero is heavily polluted with metal ions and is the main source of water for the capital city of Zimbabwe. We tested out a novel method of remediation of heavy metal ions from water that can highly promise relief to locations plagued with heavy metal pollution. We worked on developing a nano-scalable, highly efficient and reusable filter made of polydopamine (PDA), a nature-inspired biopolymer that can form coordination bonds with metal ions. The PDA membrane was synthesized using dopamine hydrochloride, ammonia and ethanol. The particles were centrifuged and the hydrogels were dried. A conventional vacuum filter was set up. Concentrations of ions such as copper, zinc and iron in water samples were evaluated before and after filtration using an Atomic Absorption Spectrometer. The membrane was regenerated using sodium citrate. As a result of the high electron affinity of the active catecholamine group as well as the pi-pi interactions between PDA and other molecules, the membrane can absorb close to 99.8% of heavy metal ions. Polydopamine is non-toxic and environmentally friendly. Its high absorbance efficiency and recyclable property will aid in reducing the country's expenditures on water treatment of heavy metal ions as this can replace the expensive methods of purifying water by *chemical precipitation*. As a result, the reduction in costs on treating water can be now invested into improving the sewer systems to reduce waste and heavy metals from contaminating the water.



Climate and Environmental Protection

2nd Place

Chinmayi Ramasubramanian



India

Averting Human-Elephant Conflict Using Machine Learning on Elephant Vocalizations

Abstract: Asian elephants are an endangered species and human-elephant conflict poses a grave threat to their existence. Human-elephant conflict refers to the negative interactions between humans and elephants such as in electrocutions and crop-raiding. Every year, more than 500 humans and 100 elephants are killed due to human-elephant conflict. A method using bio-acoustics and machine learning is proposed to build an early warning system to determine the proximity and behavior of elephants by classifying elephant vocalizations. An early warning system indicating the presence of elephants in the proximity as well as whether they are likely to raid would help curtail human-elephant conflict and prevent casualties. This system uses machine learning to detect when an elephant vocalizes and to identify the type of vocalization - Chirp, Roar, Rumble, or Trumpet. Data from recordings of 147 vocalizations were annotated and pre-processed. A unique approach was taken to train machine learning models to classify this data. Two levels of CNNs were trained hierarchically. The first level contains a CNN that classifies vocalizations into three categories - none, high frequency, and low frequency. The second level contains two CNNs that further sub-classify the vocalizations. Uniquely modified mel-scale filter banks were extracted from the vocalizations and used to train multiple CNN models. This two-level ensemble learning with hierarchical-model approach achieved an accuracy of 96.88% for the first level and 98.00% and 75.13% for the second level models. The CNN models run in real-time on a Raspberry Pi along with a uni-directional microphone and an alarm system. This early warning system raises an alarm and sends a telegram message with further information when elephants are identified.



Climate and Environmental Protection

3rd Place

Jacqueline Prawira



California, USA

Cyclo.Cloud: Development of Fish Scale Waste-Derived Materials for Adsorbance of Aquatic Pollutants

Abstract: The objective was developing a biosorbent of heavy metals by upcycling *Oreochromis niloticus* fish scale waste (FSW) to mitigate the toxic, synergistic interactions of heavy metals and microplastics in the environment. Five phases were conducted. Pretreatments to maximize removal of contaminants were evaluated through pollution exposure and adsorption capacity measurements. Phytotoxic effects on plants were evaluated for treated and untreated solutions over 7 days. SEM/EDS surface analysis and adsorption analysis were conducted. FSW was transformed into cloud form for testing with electrocoagulation. Heavy metal adsorption was optimized by deproteinization pretreatment (DP), which minimized removal of collagen and hydroxyapatite while removing noncollagenous proteins, outperforming the control by up to 24.5 percentage points. The optimal duration was 3 days, with alkaline pHs optimal for heavy metal adsorption. A positive correlation between lower optical absorbance and lower post-treatment contaminant levels (per ICP-OES) supported higher heavy metal removal rates. Plant growth improved by up to 179% and germination rates increased by 60%. Surface analysis indicated heavy metal deposits due to adsorption. Cyclo.Cloud successfully removed up to 82% of heavy metals due to the increased surface area augmenting the number of adsorption sites. Electrocoagulation enhanced removal by 3-20 percentage points. At \$0.23/kg to treat 1000L of polluted water to EPA drinking water standards, Cyclo.Cloud is a cost-effective, viable biosorbent implementable in water resource recovery facilities. Cyclo.Cloud promotes a circular economy by reclaiming polluted water, repurposing waste, and preventing toxic heavy metal impacts. Usable Cyclo.Cloud prototypes were created.



Working in Crisis and Conflict



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Regeneron International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award



Working in Crisis and Conflict

1st Place

Matthew Hansol Jabez Kim



Georgia, USA

Search and Rescue System Using Omni-Orientation Mapping Robots

Abstract: When a building collapses, survivors are trapped in unknown locations. Locating survivors is crucial in a rescue operation and can be extremely difficult due to the terrain and inaccessibility of the rubble. This project is an autonomous robotics system that can locate survivors in a collapsed building. This year's work details the first two of four parts of this project: an omni-orientation reconnaissance robot that can quickly traverse the inside of the collapsed building, a mapping program that can recreate the robot's environment, a probability fields program that references the building's schematics and the mapping program to determine probable locations of survivors, and a swarm of aerial drones to deploy reconnaissance robots. The omni-orientation robot has angled drive trains so that it can move in changing, rough terrain. The robot was able to climb an incline of 30 degrees and move while being flipped. A 3DOF differential joint was created to allow the omni-orientation reconnaissance robots to combine and move in a snakebot configuration. The current mapping program relies on motor encoders and an IMU to recreate the robot's movement and a 2D LiDAR to provide a perpendicular cross-section of the environment. The robot moves through an L-shaped, inclined rectangular prism testing course. It uses an IMU to gather orientation data to account for the inclined testing environment. Last year, the mapping program on a flat surface had a volume percent error of 11.5%. This year, the percent error was 14.53% which successfully integrated an inclined testing environment. This autonomous system will reduce the search and rescue time by directing rescuers to probable areas of survivors' locations.



Working in Crisis and Conflict

2nd Place

Sunny You



Florida, USA

Predicting Future Tropical Cyclone Intensity Using a Convolutional Neural Network

Abstract: The prediction of tropical cyclone (TC) intensity change remains one of the greatest challenges for forecasters. The Statistical Hurricane Intensity Prediction Scheme (SHIPS) is one of the most accurate models used in operational centers. The current version of SHIPS uses predictors including climatology and persistence, environmental conditions, and infrared satellite information. One critical piece of information that is missing from SHIPS is the rainfall and structural features of TCs. In this study, I proposed a novel Hurricane Convolutional Neural Network (HCNN) model to predict future TC intensity by using satellite rainfall images and existing SHIPS predictors. I designed the HCNN model to detect specific TC structures such as circular eyewall and curved rainbands for potential TC intensity change. A 20-year (2000-2019) satellite rainfall dataset was obtained from the NASA Integrated Multi-satellite Retrievals for the Global Precipitation Measurement (GPM) mission (IMERG) product for TCs from the Atlantic basin. The HCNN model was tested for 3 different radii of the IMERG data from the TC center and 200-km was selected. The model was trained using satellite images for TCs from 2000-2017 and tested using TCs from 2018-2019. Relative to SHIPS, the HCNN model with satellite rainfall input significantly improved forecasts by up to 13%, 18%, and 9% for all TCs, major hurricanes, and intensifying TCs, respectively, at 6-24 hour forecast intervals. I further integrated my HCNN predictions of hurricane intensity into a web/mobile app to demonstrate the ability of real-time applications of my model.



Working in Crisis and Conflict

3rd Place

Phong Tran and Chi My Tran



Vietnam

A Humanitarian Blood Donation Application That Facilitates the Search for Potential Blood Donors and the Smart Management of Blood Storage

Abstract: Emergency blood shortage is an urgent problem worldwide. Currently, the propaganda process, selection of blood donors and organization of blood donation are often excessively time consuming. To the best of our knowledge, there has been no application developed to serve the need to find blood donors quickly and accurately, in order to save lives in emergencies. Therefore, we have designed the “Mobile Blood Bank - MBB” application to enable hospitals to expeditiously find and contact the most probable blood donors with a compatible blood type within the closest vicinity, thereby increasing the possibility of saving lives in an emergency. The “MBB” application can track registered donors within a predefined range by integrating Google Play Service Location API. Afterward, it can efficiently predict who will be the most likely to donate blood among the people found in range by deploying the low-complexity Logistic Regression algorithm. In post-trial, the “MBB” application was evaluated based on 3 criteria “Rationale, Installation and Testing, Efficacy” by 220 medical professionals and recorded an average score of 4.41/5 on the Likert Scale- the most widely adopted approach to scaling responses in surveys. Also, trials of the Logistic Regression Algorithms returned an accuracy of 90% in predicting the most probable and suitable blood donors. By notifying potential and nearest blood donors in real-time in accordance with hospital demands, the “MBB” application has been proven to be an effective solution for finding and storing compatible blood units in a smart hospital management system during an era of digital transformation.