

Galápagos Education and Research Alliance



To promote ecological and scientific understanding in the Galápagos and the broader world

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Background



The founding members of GERA. From left to right: Ernesto Vaca, Dr. Michael Weisberg, and Dr. Deena Weisberg

The Galápagos Islands are a place of stunning natural beauty and of great scientific and historical importance. Galápagos became UNESCO's first World Heritage Site in 1978, and these Islands remain one of the most important conservation sites in the world. Indeed, 97% of the land mass and 100% of the surrounding ocean are protected as part of the Galápagos National Park and Marine Reserve. Largely as a result of these efforts, Galápagos retains 95% of its native biodiversity. This makes Galápagos extremely attractive not only as a tourist destination,

but also as a place to do science. From Darwin to contemporary researchers, it has been a hotspot for ground-breaking scientific discoveries. The archipelago is often called the "laboratory of evolution" because its high rates of endemism and near-pristine condition make it one of the best places to study evolution and ecology up close.

But Galápagos is not just home to giant tortoises and blue-footed boobies; more than 35,000 people live on these Islands. As the population grows, it puts increasing stress on the Islands' fragile ecosystem. The situation in Galápagos is not unique; similar conflicts between local communities' priorities and conservation efforts can be found the world over. But Galápagos presents a particularly acute case. These islands are relatively remote and have limited domestic resources, and any development must be balanced with the need to protect the high level of native biodiversity. Further, these issues are playing out on an international stage as the Galápagos occupies such a prominent spot in the global imagination.

Given the acute and immediate nature of these challenges, the Galápagos is more than a laboratory of evolution. It is a laboratory of education, political science, history, design, social ecology, and most importantly of understanding sustainable development and biodiversity protection in the face of massive challenges at the intersection of the human and natural worlds.

The Galápagos Education and Research Alliance (GERA) aims to support the local community in protecting biodiversity, building resilience against climate change, and promoting the health of humans and non-humans alike. GERA is a partnership between the Galápagos community and faculty at the University of Pennsylvania, Villanova University, and Virginia Tech. Our work over the last five years has focused on addressing the most pressing issues facing the Galápagos: How can the population growth in Galápagos continue while preserving the biodiversity for which Galápagos is justly famous? How can such a community prepare for the coming climate emergency?

How can the tools of community science be used to increase civic engagement with these issues and empower the local community?

We address these crucial questions by partnering with the people of the Galápagos, especially the community of Puerto Baquerizo Moreno on San Cristóbal Island. GERA is predicated on the idea that the only way to balance growth and conservation is to work together with the community of Galapagueños. We have long-term partnerships with local individuals and institutions, including the San Cristóbal Guides Association, the Charles Darwin Foundation, and the UAE-San Cristóbal School.

Unlike academic groups who have focused solely on these islands' unique biology and geology, we seek educational and research opportunities to study the entire bio/social system that is contemporary Galápagos. Moreover, we seek to do so in an ethical way that meaningfully engages the community at every level. We believe that this approach will develop the social capital necessary for Galapagueños to protect their archipelago.

GERA's current work can be divided into five main projects. The longest-running project is **LAVA** (*Laboratio para Apreciar la Vida y el Ambiente*), which consists of several community science projects researching issues of local interest. A second project addresses **public health** through improving health outcomes in areas identified as local priorities using needs assessment interviews. Third, GERA is promoting local understanding of the Galápagos ecosystem and commitment to conservation by taking locals on day trips to the national park as part of the **CON Galápagos** project. Fourth, GERA is working with landscape architects who are creating **climate resilient designs** to prevent the humanitarian disasters that could accompany climate change in Galápagos towns. Lastly, we have recently launched a **green business consulting** initiative. Experts from Penn's Wharton School of Business are working with local small business owners to stabilize their businesses during the pandemic and plan for ecologically friendly growth in the future.

The Galápagos Islands are under threat from a skyrocketing population, invasive species, and the myriad impacts of climate change. GERA is working to address these threats through meaningful and long-term collaborations with Galapagueños. Not only is this approach imperative to protecting the invaluable ecosystem of the Galápagos, but it can serve as a model of effective and inclusive conservation that can be adopted by other communities worldwide.

LAVA: Laboratorio para Apreciar la Vida y el Ambiente

“Everyone here is treated as if we were lifelong friends by the students of the University of Pennsylvania. This is important from my point of view, since the trust between each one of the members of the LAVA team conveys a positive message for all.”

-Brandon Pico, 2017 LAVA-Lobos participant

Project LAVA, *Laboratorio para Apreciar la Vida y el Ambiente* (the Laboratory for the Appreciation of Life and the Environment) is a series of community science initiatives that address issues at the intersection of ecology, conservation, and educational inequality. Our core projects deploy the tools of community science, in which local community members partner with technical experts to conceive, plan, execute, analyze, and disseminate scientific research on pressing questions at the interface between the human and non-human environment. The projects are currently based in the town of Puerto Baquerizo Moreno on the island of San Cristóbal.



The LAVA team plays some frisbee after data collection. Developing meaningful relationships with the Galápagos community is central to the approach we take with LAVA projects.

LAVA takes a three-tiered approach to community science. At the first tier is the science itself, investigating issues of interest to the local community. The second tier is an assessment of the impacts of LAVA projects and how they shape the knowledge and attitudes of participants. The third tier is a philosophical reflection on how this model of doing science with a community can inform questions about the epistemology and ethics of science.

LAVA-Lobos

“Before, I did not pay much attention to the sea lions, since I was used to seeing them all of the time. Now I view sea lions in a new way and realize that they are very important to the Galápagos ecosystem. We must conserve them, take care of them, and maintain them, because they are a unique species in the world.”

- Carlos Aldiar Predes, 2017 participant

LAVA-Lobos is a community science initiative which investigates the impact of human presence on the behavior and social structure of the endemic Galápagos Sea Lion (*lobos marinos* in Spanish). The Galápagos sea lion, *Zalophus wollebaeki*, is an integral part of the ecosystem and culture of San Cristóbal. These charismatic pinnipeds are endemic to the Galápagos and San Cristóbal is home to their largest population. The sea lions are such an iconic part of local life that they are referred to as ‘the face of San Cristóbal’.



A LAVA-Lobos researcher completes a photography protocol on Playa De Oro. Photos are being used to develop photo tagging software for identifying individual sea lions.

However, the relationship between humans and sea lions is not always positive. Sea lions compete for space on beaches with sunbathers, children, tourists, and dogs. Incidents of cross-species aggression are on the rise as sea lions chase humans out of their territory and vice versa. Some sea lions have taken to sleeping on fishing boats, leading to conflicts with fishermen who see them as threats to their livelihoods. LAVA-Lobos was initially developed after a fireworks celebration sent hundreds of sea lions racing to the ocean in a panic. Local

partners were worried about the impact these interactions may be having on the endangered sea lions, and GERA developed the LAVA-lobos protocol to investigate this concern.

The project is a partnership between the Galápagos Education and Research Alliance and a San Cristóbal high school, the *Unidad Educativa Fiscomisional San Cristóbal*. Students from the school are the primary field researchers and collect data twice weekly from July-December on several municipal beaches. They study sea lion groupings, demographics, behaviors, and responses to a human’s approach. This protocol was carried out in 2017, 2018, and 2019. Given the pandemic, our team is working to adapt the project for online learning for our 2020 participants.



A LAVA-Lobos researcher takes sound measurement on Playa de Oro. This is used as one measure of human disturbance.

At its most basic level, LAVA-Lobos is designed to answer important scientific questions about the socially and ecologically important Galápagos sea lions. In this regard, the

project has produced some interesting results. Data collected by our community researchers shows that sea lions tend to exhibit less aggressive behaviors towards humans on beaches that have greater numbers of people. However, sea lions on these beaches are more aggressive to other sea lions.



Two researchers discuss LAVA-Lobos data. LAVA strives to involve community members in all aspects of the scientific process, including data entry and analysis.

LAVA-Lobos also aims to communicate these scientific findings to the larger community in order to generate conversation about human-sea lion interactions and help create effective management plans. GERA has facilitated this communication effort through the creation of a video which was widely shared throughout the local community. We have also developed 'ride alongs' in which any local can participate in the protocol and learn about the project and about sea lion conservation directly from the high school students, who act as experts on these issues. Additionally, several LAVA-Lobos alumni have independently communicated their newfound knowledge, with one student even erecting signs at all local beaches reminding people to stay two meters away from the sea lions.

Lastly, the project is self-analytical and examines how students' participation impacts their scientific literacy and their attitudes regarding conservation. Pre- and post-participation surveys demonstrated that students became more intrinsically motivated to engage in conservation after finishing the LAVA-Lobos project.

LAVA-Mar

LAVA-Mar encompasses two projects designed to engage San Cristóbal residents with the coastal marine ecosystem bordering the municipal areas of the Island. Despite growing up surrounded by an internationally renowned marine ecosystem, most residents of Puerto Baquerizo Moreno have never interacted with the underwater world. Many locals are not able to swim or lack the confidence to swim in the ocean. In addition, snorkeling or scuba diving tours are economically infeasible for most locals. As a result, very few Galapagueños have explored the ocean in their front yard. Yet they know that these nearly pristine waters of are not what they once were. At low tide, they can smell raw sewage entering the bay in front of their town, they can see irritation in the skin and eyes of sea lions, and older residents attest to a loss of marine biodiversity in local bays.



GERA team members with the Wreck Bay Dive Club after conducting a benthic survey.

LAVA-Mar aims to facilitate ocean activities for locals through both scientific projects and experiential and educational opportunities. The first project is being carried out in partnership with the Wreck Bay Diving Center. The Wreck Bay Dive Club, led by naturalist guide Ivan Lopez, is training local middle-schoolers to receive their PADI diver certifications. In 2019, GERA partnered with Lopez to teach these students scientific diving skills and pilot a research program aimed at assessing the benthic composition of local bays. This project has continued in 2020 with Penn students leading virtual training sessions on marine biology, scientific methodology, and diving skills. As the dive club adapts to COVID-19 regulations and opens for diving, the students will once again start collecting data.



A GERA team member helps a local dive student to master scientific diving skills.



A group of differently-abled school children use the underwater drone.

The second project utilized an underwater drone to offer virtual snorkeling experiences to Galapagueños. In partnership with the National Park, GERA led three community outreach sessions in which the drone was placed in Wreck Bay (the bay in front of the town of Puerto Baquerizo Moreno) and footage was livestreamed to participants on land. This allowed individuals who are often excluded from marine activities due to their inability to swim (including a group of elder locals and a group of differently-abled school children) to experience the marine ecosystem.

LAVA-Agua



A GERA team member teaches a group of local scouts the LAVA-Agua protocol.

LAVA-Agua is a project to study the domestic water supply. San Cristóbal is the only inhabited island with flowing fresh water. However, even though the freshwater undergoes some treatment at a local plant, water on San Cristóbal is not potable due to presence of coliform bacteria. Coliforms are typically found in animals' digestive tracts, and although they are not necessarily harmful, they can indicate the presence of other potentially deleterious bacteria. Not only might coliforms be harmful to human health, but

the lack of potable water in the Galápagos Islands increases the use of imported water in plastic bottles and containers. The archipelago's reliance on bottled water contributes to more plastic litter and microplastics contaminating the environment.

To address these issues, LAVA-Agua works with individuals, households, and businesses to test their water supply. By testing the water from their own faucets, participants learn scientific techniques and gain an understanding of the purity standards for clean drinking water. At each site, a simple water quality test strip and coliform test broth is used to test water for the presence of coliforms along with lead, iron, copper, chlorine, nitrate, nitrite, hardness, pH, alkalinity and turbidity levels.



A GERA team member performs water tests in a local household.

Preliminary testing of tap water on San Cristóbal in 2018 found that the majority of tap water samples had coliforms present, while only one location tested positive for chlorine in the water at tap. Chlorine is necessary to kill harmful pathogens and its absence highlights issues with water quality. We expanded our approach in 2019, conducting tests in 52 homes and businesses and partnering with a local Scout troop to deliver educational content around water quality. We are also developing protocols that can be used in other settings, like schools, to teach the protocol and to educate students and their families about water treatment.



Example of coliform test performed as part of the protocol.

Data collected from this project will be used to map the coliform levels throughout Puerto Baquerizo Moreno homes and businesses, establish tools for treating drinking water at tap, and present the findings of the water testing and clean water systems to the community, including to municipal and regional authorities.

LAVA-Agro

LAVA-Agro aims to provide scientific research with and for the agricultural sector of San Cristóbal Island to inform the reactivation of agricultural lands that have

been colonized by invasive species. The project is in its beginning phases, and studies performed in summer 2019 lay the groundwork for its expansion in the future.

The invasive of focus in our 2019 pilots was *Rubus niveus*, a blackberry species described as “the worst weed in the Galápagos.” For our investigation, the GERA team cleared several previously infested plots of land in the San Cristóbal highlands and tested the effectiveness of planting different native and agricultural species at preventing blackberry regrowth.



GERA team members clear a patch of invasive blackberry.



A GERA team member records the rate of blackberry regrowth in one of our experimental plots.

The results from the study will be used to inform the development of agricultural strategies to effectively clear and control the blackberry. This in turn will improve the efficiency and abundance of local agriculture, contributing to the community's ability to locally and sustainably source their food.

Con Galápagos: *Iniciativa para Conocer Galápagos*



A Con Galápagos group lands on Isla Lobos.

Galapagueños' lives and livelihoods are intimately linked to the archipelago's limited resources, and they are the ones most impacted by conservation restrictions. Yet few Galapagueños have had the opportunity to experience the park they protect; exorbitant prices limit park access to researchers and international tourists. We believe that the Galapagueño community must have the same opportunity to come to know (*conocer*) the National Park as is afforded to tourists and scientists.

As former Ecuadorian Vice President Otto Sonnenholzner said in his recent visit to the University of Pennsylvania, "You cannot love what you don't know, and you will never take care of what you don't love... We have to start knowing what we have so that we can take care of it. That's what Penn is doing in Galápagos, and I really applaud it."



A GERA team member talks to two of the participants of the 2019 pilot.

Con Galápagos thus aims to improve local understanding of the Galápagos ecosystem through exposing locals to national park sites in a substantive way, as it is seen by tourists and scientists. This is done with the eventual goal of improving attitudes towards conservation.



GERA team leader and naturalist guide Ernesto Vaca leads a walking tour on Isla Lobos.

This project took two pilot trips of local women to Isla Lobos in 2019. Participants were deeply engaged in the trip and supportive of a wider implementation of the project. Four more pilot trips are being planned for 2020 in partnership with the Puerto Baquerizo Moreno Tourism Department.

Public Health/One Health

In recent remarks at Penn, former Ecuadorian Vice President Sonnenholzner stated, “we can’t expect people to keep their environment healthy when they aren’t healthy themselves.” Galapagueños have among the highest rates of diabetes, obesity, and related diseases in the country. At the same time, the natural environment of Galápagos is threatened by the fact that 99% of food is now imported, even though available agricultural lands lie fallow. Further, waste treatment is in a terrible state, and raw sewage is routinely pumped into the ocean on the four inhabited islands. GERA views these circumstances as opportunity to pursue the One Health approach on the Islands, drawing expertise from the fields of Public Health and Veterinary Medicine.

In 2019, the GERA public health team undertook an initial community health needs assessment to identify high-priority topics. This team is currently developing a set of public health projects including ongoing community participatory research, as well as educational campaigns on the identified high-priority topics, including nutrition and teen pregnancy prevention.

The second focus of the public health project is sewage. Due to inadequate infrastructure, raw sewage frequently is pumped into the harbor in front of Puerto Baquerizo Moreno. This poses a serious problem for human health, for the health of the aquatic ecosystem, and also for companion animals living in town. To begin to address this issue, we plan to use targeted diagnostics to quantify fecal contamination in municipal and Park water supplies. We will employ a hand-carried, battery-operated device controlled by a smartphone and use it to assay up to 9 samples in about 40 minutes. GPS coordinates are recorded automatically each time a smartphone is used to operate the device, thereby allowing assay results to be geospatially mapped on the island. This will produce results that are maximally impactful, since specific geolocations with contaminated water can be targeted for follow-up testing and can help to guide future Park conservation efforts. Finally, the portability of this device and its seamless integration with smartphones provide a powerful way to engage with and educate local community members about aspects of human and animal health. We intend to leave this equipment in place in order to build local capacity.

Climate Resilient Design



3D Topo-Bathy model of Puerto Baquerizo Moreno created with novel drone mapping technique. Such models are essential for climate resilience planning.

The Alliance design team includes landscape architects working to create climate resilient designs in order to prevent the humanitarian disasters that could accompany climate change in Galápagos towns. According to recent reports from the Intergovernmental Panel on Climate Change (IPCC), we are already seeing substantial effects of climate change. These changes will continue to become more extreme, even under the most aggressive carbon reduction plans. In order to prevent the

humanitarian disasters that could accompany these radical changes, both the IPCC and the United Nations Framework Convention on Climate Change (UNFCCC) recommend substantial efforts to build resilience and to begin adapting to our changing climate. Most of these efforts are necessarily local: Every community will be impacted differently by sea level rise, higher temperatures, and disappearing fresh water. However, there is currently little effective interface between local knowledge and the scientific review process of the IPCC. One way that our project team aims to address this gap is by developing local capacity to understand the risks of climate change and to plan effectively for the future. Specifically, we plan to engage Galápagos communities in reimagining their waterfront and their growth patterns to minimize the effects of climate change.

We do so in two ways. First, we will continue construct accurately referenced geospatial models. These models require the integration of spatial data across land and sea in order to create a continuous topo-bathy model. This continuous surface is essential for modeling applications that span the land-water interface, such as inundation from storm surge or tsunamis. The topographic and bathymetric data available for creating such models is often too coarse, outdated, or altogether absent. Furthermore, the collected bathymetry cannot be related to the shore without a referential datum. Creating an accurate, spatially referenced surface requires the use of multiple data sets, a process that is complicated by data set mismatches of reference, scale, resolution, collection type, or date. Resolving these mismatches by establishing a uniform reference and using data integration techniques is essential to such a foundational construct.

We have already constructed a proof-of-concept model for the shoreline of Puerto Baquerizo Moreno (see picture above), and now we aim to extend our work to the three other inhabited islands, using dual-frequency GPS-enabled unmanned aerial vehicles (UAV) and unmanned water vehicles (USV). These vehicles will enable us to obtain up-

to-date, high-resolution data, which will be used to create a spatially referenced, merged topo-bathy model of the littoral zone so that analyses for tidal gauge data and patterns, flood, inundations, and rising tides may be more accurately assessed and modeled to promote resiliency efforts. More than a mere presentation or quantification of existing conditions, these new collection methods and models give landscape architects a means to better envision the temporal dynamics of a changing environment. This model has been shared with INOCAR, the Ecuadorian equivalent of NOAA.

The second part of our project involves engaging the community in thinking about climate change resilience. Under all carbon emission scenarios considered by the IPCC, coastal areas (including islands like Galápagos) will experience extremely amplified anomalous conditions, including submergence of land, enhanced flooding, erosion of land and beaches, salinization of soils and groundwater, loss of or change of ecosystems, and impeded drainage. These impacts are expected to greatly increase along island coastlines, unless proper adaptation strategies can be adopted.

Given this, what will happen to people living along the coast? And what will happen to the whole town if current development trends continue, leading to increased damage from storm surges and more frequent flooding? In our view, answers to these and other crucial questions can only be addressed by engaging the local communities. Design proposals will be used to engage residents in imagining the impacts of future growth and climate change on their island and discussing options for improving the urban environment, which has not received the same attention as the protected areas of the National Park.

To begin a process of dialogue about these issues and their possible solutions, we had planned to hold a joint UNFCCC / GERA Climate Resilience event in the town of Puerto Baquerizo Moreno in 2020. This plan was disrupted given the global pandemic, so we are currently developing an alternative mode of community engagement, likely the circulation of a video outlining design projects and development goals.

Green Business Consulting

The green business consulting initiative is the newest GERA project. This project aims to work with Galapagueños to establish, grow, improve, and maintain economically sustainable and environmentally friendly small businesses. Working with experts from the Wharton School of Business at the University of Pennsylvania, we are pairing students with Galápagos business to construct business-specific development plans.



This initiative is based on two core beliefs. First, a healthy economy is critical to a healthy community. Therefore, the program strives to provide small business owners with prudent business guidance that gives them the best chance of financial success. Second, all Galapagueños deserve to live, work, and relax in a clean environment. As such, the program strives to deliver best-in-class “green” guidance to small business owners to ensure their business operate in an environmentally friendly way.

Naturalist Guide Fausto Rodriguez, bottom right, owns Galapagos Best, a tourism company that participated in the consulting program.

This program was launched in the summer of 2020.

As such, it quickly

pivoted from working on encouraging businesses to become more sustainable to assisting local small business owners to stabilize their businesses during the pandemic. We were also able to focus on ways to grow these businesses in an ecologically friendly way after the pandemic. Five small businesses from Santa Cruz and San Cristóbal were involved in the first round of this project. These businesses were in different stages of development and represented different sectors of the economy, including a farm looking to expand sales of its primary crops, a tour operation aiming to diversify its operations in light of the pandemic, and a daughter-father team hoping to open a sandwich shop to bring healthy and locally-sourced food to the community.



The "smoking-bird" sandwich. One offering from the soon-to-open sandwich shop run by Ernesto Vaca and his daughter Fabiola.

Planning for the next round of consulting, to take place in summer 2021, is currently underway.