Puerto Rico (University of Puerto Rico Mayaguez Campus) Annual Report - FY2023

Review Report

Contributing Organizations

University of Puerto Rico Mayaguez Campus

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Executive Summary

Overview

This annual report includes what the University of Puerto Rico's (UPR) Agricultural Experiment Station (PRAEXS) and Agricultural Extension Service (PRAES) consider to be our most salient research and educational achievements during FY2022-2023. While Hurricane Fiona hit the island at the start of the period, affecting research projects with planned field activities, most were able to adjust their work schedules and fulfill the objectives planned for the year. Also, although our budget remained stagnant, for the first time in many years funding for new regular faculty and non-faculty appointments was assigned to UPR-Mayagüez by the UPR's central administration and we began the process of recruiting a limited number of strategically important positions. New faculty members are expected to begin in 2024, strengthening research and education efforts in Agroecology, Agricultural Economics and Rural Sociology, and Animal Sciences.

As in previous years, collaborations between PRAEXS and PRAES continue to leverage progress and many of the achievements made in shared critical issues. Highlighted bean breeding and specialty crops research, and results from PRAEXS seed production programs, contributed to PRAES' featured success in helping to increase sustainable vegetable and grain production and in establishing new bean farms. Likewise, research results on potentially toxic contaminants in urban soils are being integrated by PRAES into workshops that provide guidance on how to minimize exposure to these contaminants in communities interested in strengthening their resiliency to natural disasters by establishing home and community gardens.

This report includes accomplishments and results from the following six Critical Issues defined in our 2023-2027 approved POW:

1. Food Security, Plants and Animal Systems
2. Extreme Weather, Natural Resources and Environment, and Sustainable Energy
3. Food Safety, Science and Technology
4. Community, Economy and Sustainable Development
5. Family and Well-Being
6. Positive Youth Development

"Food Security, Plants and Animal Systems" continues to be the critical issue that concentrates most of our research and extension projects and programs. More than 60% of our research projects are contributing to this issue's progress. Highlighted research in eleven plant and animal systems projects represents part of the diverse approaches followed to solve the identified problems. The release of locally adapted cultivars resistant to major diseases that limit production, coupled with new technologies and advances in the correct identification of plant pathogens and pests, are important contributions for devising and updating integrated pest and disease management plans. Trials with strategies that improve the resilience of agroecosystems to weeds, pests and pathogens, such as integrating cover crops and companion crops into sustainable management plans, also show promise in helping transitioning organic and agroecological farmers meet their goals. In animal systems, progress achieved at improving knowledge of Puerto Rican slick-haired cattle will be important for accurate selection of animals, and subsequent increase in the efficiency of milk production on dairy farms. Likewise, results related to improving the profitability of Creole ewes and on the best forages, and other nutritional strategies for cattle, are important steps in the quest to improve economic returns for small ruminant and livestock producers. In response to the decline in Puerto Rico's bee population post-Hurricane María, the Honeybee Research and Extension Program was launched to boost bee numbers and ensure pollination. Targeting honey enthusiasts, beekeepers, and bee removers, the program provides training on effective colony management and honey production. The PRAES Urban Poultry Farming initiative promotes

food security by empowering students to raise backyard chickens, teaching essential farming skills. With 357 students benefiting initially, collaboration with local producers resulted in a successful egg hatching program. The PRAES Enhancing Crop Health program has aided over 200 crop producers, leading to increased crop yields and the establishment of new vegetable farms. Collaboration with the "Seeds for my Land" initiative facilitated the growth of bean farms, contributing to the resilience of the vegetable industry.

The "**Extreme Weather, Natural Resources and Environment, and Sustainable Energy**" critical Issue is also an important research program for PRAEXS. Almost 20% of our total projects contribute to this issue's progress. The four featured research projects share a concern for soil conservation and the measurement and improvement of soil quality parameters that affect soil fertility and the productive capacity of crops in different ecosystems. Identifying agricultural practices and locally available inputs that can improve the conditions of soils and the establishment of a management guide for soil quality parameters are some of the expected outputs of these projects. Through the PRAES Natural Resource Protection Amid Extreme Weather And Natural Disasters program stakeholders were empowered with valuable insights, enhancing resilience to extreme weather. Positive outcomes include changes in soil management on 79 farms, adoption of conservation practices by 36 individuals, and improved agricultural resilience for over 110 participants. Notable success stories include erosion mitigation strategies and sustainable farming techniques. The program's objective is to mitigate climate change's adverse effects on Puerto Rico's agriculture, promoting sustainability and safeguarding natural resources for the wider community's benefit.

Research projects in the "**Food Safety, Science and Technology**" critical issue continue to monitor food safety issues that may present a challenge to small farmers operations or a human health hazard, while also assisting in the search for alternatives to add value to farm products. This year's highlighted results show progress achieved in value-added alternatives for coffee and yam, and in activities related to helping small farmers comply with FSMA water requirement in the Produce Safety Rule. PRAES continues tackling pertinent food safety challenges in Puerto Rico, aiming to educate individuals and families. Key personnel from various institutions engaged in food safety training sessions, including School Food Authority, Head Start, State Insurance Fund, Family Department, and Vocational Rehabilitation. Additionally, in compliance with Health Department requirements during inspection visits, educational materials were created for food establishments, serving as crucial reminders to employees regarding safe food handling practices.

Finally, in our smallest program, two research projects under PRAEXS "**Community, Economy and Sustainable Development**" critical issue were highlighted for their contribution towards the viability of coffee grown in the central mountainous region of Puerto Rico, an economically depressed area where agriculture needs to be stabilized and regenerated. In terms of PRAES, the Community Self-Management, Economic Development, and Volunteers' Resilient Projects during Critical Times program initiated strategies like community gardens and secured grants to enhance food security. In Puerto Rico's mountainous regions, we're developing new agricultural enterprises to diversify food supply and create livelihoods. Distance education centers have been established to overcome accessibility barriers, improving participants' technological skills and fostering aquaponic system progress. Additionally, we're supporting coffee farmers with projects to improve labor efficiency and quality, sparking innovation in the industry.

Under the "**Family Well Being**" critical issue, the PRAES Health and Well-being program focused efforts on educational activities on physical and mental health yielded significant outcomes: increased awareness, adoption of healthy practices, and preventive measures against chronic diseases and cancer. The Food Security program educates individuals on healthy eating, food prep, safe handling, home cultivation, budgeting, and preservation methods. It also offers guidance on nutritional assistance and community garden involvement, with personalized counseling for enhanced outcomes. Over 7,500 individuals benefited from the educational activities of this program, improving their food security status.

Through the Teens Leading the Change for Community Wellness and the 4-H Equity Challenges: Inclusive and Diversity Ways to Support Youngers programs, important achievements were reported under the "**Positive Youth Development**" critical issue. These programs promoted 4-H teen leaders and members to collaborate with community organizations and universities across the island. PRAES Extension Educators mentored and assisted them in organizing workshops and creating educational materials focused on food preservation. Additionally, interdisciplinary activities that supported and advocated for more educational opportunities for young people included the Bee Team initiative, 4-H Pathway to a Healthy Life, Access, 4-H Painted for Others, Explore and OYE.

Critical Issue: Community, economy & sustainable development

Despite the passage of several years since Hurricane Maria in 2017, seismic events in 2020, and the challenges brought by COVID-19 in 2019-2022, communities, both in mountainous and other areas, persistently persevere in their efforts to organize and strengthen resilience. Puerto Rico Agricultural Extension Service (PRAES) personnel, armed with specialized training not only to instruct but also to empower farmers and community organizations, play a pivotal role in catalyzing the restructuring of community frameworks. Their dedicated endeavors aim not just to address immediate needs but to foster enduring adaptability and strength within these diverse communities, recognizing vulnerabilities in economic development, food security, and resilience.

To address the concerns of the communities and assist them in crafting initiatives to fulfill their needs, we implemented a range of strategies and initiatives aimed at fostering increased resilience. Stakeholders specifically emphasized the importance of training in areas such as income generation from existing activities, diversification of food sources, and the enhancement of distance education. Consequently, we initiated community gardens that empowered communities to attain food self-reliance and financial independence, fostering the creation of self-sustaining communities.

The Wellbeing Association of Marías Sector in Aguada, Puerto Rico, guided by an exceptionally blind couple, is one of 11 community organizations actively enhancing their skills for greater resilience. Through collaboration with Community Resource Development (CRD) Extension Specialists, they successfully secured a $164,000 grant from Puerto Rico's Food Bank, enabling them to acquire agricultural produce directly from local farmers, expand their kitchen,

and acquire a cargo van. This initiative has empowered them to distribute over 17,000 meals and 3,600 boxes of locally sourced agricultural products to families in need, significantly bolstering food security within their community.

The mountainous area of Puerto Rico is renowned for producing various crops, but not so much for animal protein, especially fish. This renders the region vulnerable in meeting its food needs after a disaster or emergency. Furthermore, the mountainous region experiences the highest levels of unemployment and poverty, making it the perfect scenario for the development of new agricultural enterprises that can diversify the food supply and provide livelihoods for new generations of farmers.

One of the main limitations faced by mountain communities and farmers is the accessibility to educational opportunities. After Hurricane Maria, the roads have become less passable, increasing the barriers of distance and time for these communities to attend training sessions offered by PRAES in distant locations. Distance education can provide an alternative to enhance educational opportunities; however, many remote communities lack the necessary equipment and skills to benefit from new technological tools.

With funding from the Distance Education for Community Aquaponic Production Project, five (5) distance education centers were established in the participating communities. Sixty-six (66) participants received certificates for completing contact hours in distance education. Pre and post-test data reflected notable improvements in participants' technological skills, such as:

- connecting to Moodle community (Pre: 33% vs Post: 89%),
- creating remote meetings in Teams (Pre: 55% vs Post: 81%),
- uploading photos or videos on WhatsApp (Pre: 81% vs Post: 97%).

The participants showcased their proficiency by sharing videos and photos of their aquaponic systems' progress, and a virtual library on YouTube was developed to deposit project-related class videos. Eventually, these materials will also be accessible on the PRAES web page under the Project.

On the research side, PRAEXS highlighted projects have focused on a formerly important commodity in the central mountainous region of Puerto Rico. Coffee, while no longer a principal crop in terms of market value of production, is a vital component of the central region’s farming system and community way of life which still harbors 38% of small and medium farmers on the island. Besides been affected by the increasingly frequent and devastating hurricanes of the last decade, coffee production has been limited by the lack of labor during harvest season. To remain viable with a reduced production volume many farmers try to differentiate their produce by emphasizing quality and other attributes of their crop, and by attracting discerning consumers of specialty coffee willing to pay more for a perceived superior cup. Improving the efficiency of the available labor is an integral part of this strategy. By examining consumer’s attitudes and behavior towards information provided in the packaging of coffee, one of our highlighted projects shared with coffee farmers results that can be used in the design of more effective marketing strategies. Similarly, experimental work conducted testing alternative coffee harvesting methods against the traditional basket, already have preliminary findings that have been shared at industry meetings. As reported, these results have “sparked interest and dialogue among coffee producers about adopting innovative practices that promise to address labor shortages and improve coffee quality”. Combined with initial activities documenting possible relationships between major diseases in rural areas and declining agricultural production, and a preliminary update of the most pressing issues facing farmers, projects related to this topic are advancing the research and education agenda established in our POW for the regeneration of agriculture and employment.

Critical Issue: Extreme weather, environment, natural resources, and sustainable energy

Extreme weather events are increasingly common contributors to soil erosion, which poses serious threats to watersheds, particularly in Puerto Rico where prime agricultural land is limited. The island's diverse agriculture, dominated by small family farms, faces escalating challenges from land degradation due to urbanization and erosion. To address these issues the Natural Resource Protection Amid Extreme Weather And Natural Disasters implements conservation agricultural practices, advocating for soil and water conservation, and promoting urban agriculture and composting initiatives that are crucial mitigation strategies for safeguarding Puerto Rico's agricultural future.

The main activities that contributed to achieving the program goals and objectives included educational efforts to lessen climate change's effect on farming in Puerto Rico through enhanced practices, soil conservation, and urban agriculture promotion. Training, both in-person and virtual, were provided to farmers and stakeholders island-wide. These endeavors were especially crucial post-Hurricane Fiona's impact in September 2022.

Workshops and training on soil improvement were conducted for agricultural agents and farmers in Puerto Rico. Four workshops covered soil sampling, analysis, and nutrient recommendations, while eight training courses focused on soil management and fertility, attended by 23 farmers. Soil samples from 30 farms were analyzed, and recommendations were provided. Collaborations between PRAES and NRCS helped spread soil nutrient management information to farmers, producers, and the public.

Urban agriculture holds potential for enhancing community resilience to natural disasters. However, it faces challenges like soil contamination. To address this, three workshops were held to promote home and community gardens, focusing on mitigating exposure to contaminants. These workshops, attended by over 100 participants, combined theory with hands-on activities, empowering individuals to cultivate safe and sustainable urban gardens.

Educational workshops focused on soil erosion control, watershed protection, and agricultural resilience to climate change, engaging over 166 participants. The sessions also provided specialized training in agroforestry and emergency disaster management. Another set of workshops, based on the PRAES curriculum guide, attracted 186 participants and included specific training on emergency disaster management for 22 individuals to support farm

sustainability.

Through the educational activities mentioned above, our targeted audience gained valuable insights and subsequently adopted recommended practices. This proactive approach has significantly enhanced their resilience to extreme weather events.

Training on soil management and conservation resulted in positive changes on over 79 farms, with six farmers adopting soil amendments and five adjusting fertilizer choices. Additionally, 36 individuals implemented recommended conservation practices, and 32 enhanced soil fertility methods.

More than 110 individuals/farmers adopted practices to enhance agricultural resilience and protect natural resources, including ground cover and improved water collection systems. 142 volunteer hours were dedicated to preparing for extreme weather events. Notably, a success story involved a farm using terraces and integrated farming techniques to cultivate San Marzano tomatoes without erosion. Another farmer in Lares received guidance on erosion mitigation strategies post-Hurricane Fiona.

The program's objective is to mitigate the adverse effects of climate change and extreme weather on agricultural production in Puerto Rico by advocating for sustainable practices, soil and water conservation, urban agriculture, and composting. This initiative extends its benefits to the wider public, ensuring the preservation of natural resources while bolstering food security and local sustainability. Moreover, it fosters the protection of essential resources crucial to the island's economy, energy supply, recreational opportunities, and overall aesthetic charm.

Seven years after Hurricane María, the most catastrophic atmospheric event to hit the island of Puerto Rico, the consequences are still palpable, especially in our agricultural production. With the intention of withstanding the long-term effect of extreme weather events, the Agricultural Experiment Station has encouraged its researchers to develop projects that promote resilience. Projects highlighted this year share a concern with soil conservation, and the measurement and improvement of soil quality parameters that affect soil fertility and the productive capacity of crops in different ecosystems. Identifying agricultural practices and locally available inputs that can improve the conditions of soils and the establishment of a management guide for soil quality parameters are some of the expected outputs of these projects.

In *Agroecological Practices Adapted to Extreme Weather Conditions,* researchers acknowledge that under the current climatic conditions soil conservation is a particular challenge due to excessive rain during rainy season and excessively drier dry seasons. The project is evaluating soil health changes under five cover crops plants in six soils of six different orders, under three moisture regimes. Significant progress was achieved this year in the project's primary goal of tailoring soil conservation practices, as corrective and preventive actions, to specific soil order and climatic conditions.

Extreme weather events can also result in multiple challenges to the development of agricultural production in urban soils. Besides the legacy of contamination of these soils with a range of chemicals of emerging concern, soils and water can also be contaminated due to accidental spills, as was the case in 2017 during the category 4 hurricanes Irma and Maria. The project *Identification and distribution of potentially toxic contaminants in Puerto Rican soils* aims to map anthropogenic contaminants in rural and urban environments that could help establish safeguards to avoid the risks involved with these contaminants. The methods of analysis for each class of contaminants have already been determined and the identification of sites with possible contamination, as well as collection of soil samples at these sites, is currently underway. Expected results will be important for the creation of an economically sustainable and efficient soil rehabilitation system that could provide resilience to urban gardening efforts.

Researchers of soil quality know that management practices can differ by region due to soil properties, climate, and predominant crops. In *Soil quality assessment among soil order and ecological zones in Puerto Rico* major soil quality parameters were determined for two Oxisols from the island's northwest and two Mollisols from southern Puerto Rico. At the mountain region, an Oxisol and an Ultisol were evaluated. Results will be used to establish a management guide for soil quality parameters and increase the knowledge among farmers, technicians and the academic community on soil quality preservation and improvement. Finally, although still in an early stage of its planned work, the project titled *Low cost and locally available inputs and sustainable practices for increasing the resiliency and sustainability of food crops,* started to collect and characterize locally available agricultural inputs such as seawater and ashes. The expected results will provide information on how these and other inexpensive agricultural inputs can improve soil health while increasing crop yields at any surface scale (a garden or commercial farmland).

Critical Issue: Family well-being

PRAES Health and Well-being program address challenges related to the health and well-being of individuals and families in Puerto Rico. Specifically, those related to chronic diseases, obesity in adults and children, breast and cervical cancer, depression, anxiety, and suicide. In addition, individuals and families in Puerto Rico face critical challenges related to food security. This program intends to improve the knowledge and adoption of good practices related to food security in individuals and families of Puerto Rico through education and counseling.

Dissemination of information through seminars, conferences, and participatory workshops helped the Extension personnel reach diverse audiences, which extended the program's reach. Through these activities, Extension educators give a chance for the targeted audience to ask questions, share stories, and get inspired to make positive changes to their lives, helping the program to effectively inspire changes in attitudes.

The use of interactive courses and recreational activities not only provided knowledge to our audience but also created an enjoyable environment that inspired us to adopt and maintain healthy habits. In conjunction, these activities helped to achieve the program's goals.

During Fiscal Year 2023, a comprehensive set of educational initiatives, including courses, seminars, workshops, and distribution of printed and digital materials, was implemented to promote awareness of physical and mental health. Some of the most salient outcomes included:

- 815 individuals reported an increase in their understanding of lifestyles promoting good mental health; 1,556 gained insights into personal care and well-being; 4,518 indicated an improvement in their knowledge of healthy lifestyles; 484 individuals acquired information about practices for preventing chronic degenerative diseases, and 383 people learned about early detection of breast and cervical cancer.
- 228 individuals reported embracing practices to support good mental health, 381 people adopted skills and practices to enhance their personal development and overall well-being, and 849 individuals confirmed the adoption of one or more recommended practices for promoting healthy lifestyles. Moreover, 309 individuals said that will apply skills to find and manage their emotions healthily, thereby preventing depression; 84 individuals adopted one or more measures to prevent the development of chronic degenerative diseases and 184 individuals acknowledged the importance of preventing and detecting breast cancer and cervical cancer early on.

Empowered individuals are well-positioned to make informed decisions about healthy lifestyles. Educational initiatives play a pivotal role in empowering the community, offering practical insights and resources that cultivate a culture of informed decision-making and proactive health management. Ultimately, this approach contributes to enhanced well-being and cultivates a community that is more health-conscious and proactive about their health.

Training serves as a fundamental resource for families to address food security challenges. The program's educational activities focused on instructing individuals on various aspects, including promoting healthy eating habits, effective food preparation, safe food handling, growing food at home, budgeting for food, and employing methods of food preservation and storage, such as home canning, dehydration, freezing, cooking, and the use of Mylar bags. Other activities encompassed guidance on nutritional assistance programs, participation in community gardens, and related initiatives. To enhance and steer the expected outcomes, personalized advice was offered.

Through the Food Security Program, 7,947 individuals acquired and enhanced knowledge about healthy eating, safe food handling, growing food at home, and food preservation techniques.

- 1,120 individuals reported improving the quality of their diet by selecting nutrient-rich and low-calorie foods and beverages.
- 595 individuals adopted recommended safe food handling practices.
- 596 families grew food at home.
- 699 individuals adopted food preservation techniques.
- During FY 2023, 50% (249 families) of the goal of establishing a 5-day food reserve as a strategy to address emergencies and food insecurity was reached.

By educating individuals on improving local food security, the broader public stands to benefit from increased awareness and knowledge about sustainable agricultural practices, leading to enhanced community resilience against food shortages. Empowered individuals are better equipped to make informed choices in growing, preserving, and selecting nutritious foods, fostering healthier communities. A well-educated population on local food security contributes to a more sustainable and equitable food system, positively impacting the overall well-being of the broader public.

Critical Issue: Food safety, science and technology

As described in our POW, PRAEX's research efforts on this critical issue have two main focuses: safeguarding food production and adding value to local produce through processing and other means of extending their shelf life. Activities related to the first one in the project *Enhancing Microbial Food Safety by Risk Analysis* were geared to helping small farmers comply with FSMA Produce Safety Rule (PSR), particularly with agricultural water requirements. Among other activities, agricultural water samples were taken on the visited farms and a laboratory experiment was conducted to study the risk of internalization of cucumber according to farmers' post-harvest practices. The results have helped small farmers demonstrate compliance with the water requirement in the PSR.

Progress was also achieved last year in projects aiming at providing value-added alternatives to local crops. In coffee, to remain viable, farmers need to command a higher price for their product. Their current strategy relies on producing high quality specialty coffee and on devising other alternatives to add value to their crop. The *Development of High-Quality Value-Added Products Made from Coffee* targets this need. Activities during the year included the training of students in the project's different stages and assembly and evaluation of the proposed aroma extraction systems. Several modifications in these systems are currently being tested and their validation and optimization of operating parameters will continue. Expected results, after concluding the experimental stage of the project, include the generation of methods to help manufacture value added products with potential to be commercialized.

In yam, a crop whose production has been declining, PRAEX research activities in other programs are including the production of disease-free seed of yam through plant tissue culture, and training farmers in high-quality seed production and post-harvest storage of the crop. When good quality crops are obtained farmers prefer to sell the entire yam for fresh consumption. However, increased seed availability may stimulate farmers to expand production and sell it to produce flour if a tested processing method to produce yam flour and composite blends is available to the industry. The project *Manufacture of Yam (Dioscorea rotundata) flour as a possible ingredient in the preparation of pasta, bread, and extruded products* has the objective of finding the best processing methods to accomplish this task and produce a yam flour that can be used to prepare diverse products. Already the proximate composition, physicochemical, and rheological characteristics of prepared flour from two yam cultivars have been investigated. Results from the enthalpy of

gelatinization of the flours showed that yam flour possesses a high gelatinization temperature; its use can therefore be recommended for products, such as canned foods, which require high processing temperatures. These results will be delivered to scientists working with technology for processed vegetables in the public and private sector.

PRAES continues tackling pertinent food security challenges in Puerto Rico, aiming to educate individuals and families. Pertinent to this period, 1,031 individuals completed and passed the food safety manager course, aligning with Conference for Food Protection Standards. Notably, 900 of these participants adopted three or more recommended food handling practices, including temperature control, proper hot food maintenance, handwashing, glove use, and separate cutting board utilization. Key personnel from various institutions engaged in food safety training sessions, including School Food Authority (102 food handlers), Head Start (50 kitchen employees), State Insurance Fund (13 employees), Family Department (6 people), and Vocational Rehabilitation (2 people). Additionally, in compliance with Health Department requirements during inspection visits, five posters were created for food establishments, serving as crucial reminders to employees regarding safe food handling practices.

Critical Issue: Food security, plant & animal systems

Under the long-term vision of regenerating agri-food production in a sustainable manner in the face of climate change and demographic challenges, progress has been made in different components that contribute to increasing food security in Puerto Rico. PRAEX long-term project on breeding *Phaseolus* beans continues to develop marker-assisted, locally adapted cultivars resistant to major diseases that limit bean production. New black, pinto and white bean cultivars with resistance to common blight, should reduce losses in yield & quality caused by disease and permit more production during the hot and humid summer months. Protocols for using novel technologies that promise higher accuracy and reliability for the early detection and management of plant pathogens were evaluated and a *Loop-mediated isothermal amplification* (LAMP) assay for the early detection of P. fijiensis (Black streak) in plantains and bananas was developed to help prevent the spread of the disease in PR. Equally important is the development of management protocols that could reduce population outbursts of pests limiting the production of export crops, such as mango, in the south coast of Puerto Rico. Producers there reported outbursts of stem borers but they had not been accurately identified nor quantified. Experiments performed this year to evaluate the severity, incidence, and preferences of *Batocera rufomaculata* in mango cultivars (cvs) show preferences towards certain cvs. The severity depended on multiple biotic and abiotic factors.

Concluding research on specialty tomatoes and Asian vegetables provided data on these new crops adaptation in different production systems, along with protocols to overcome post-harvest challenges. Amply disseminated results include pests' management practices and identification of new markets. An important outcome of this project has been the documentation, through market and value-added surveys, of stakeholders' interest in having these new specialty crops added to the Department of Agriculture's list of crops allowed to be marketed in their "Family Markets". Family Markets are itinerant farmers markets that offer an important outlet for selling local produce. Finally, two highlighted projects focused on cover crops contribution to sustainable agroecosystems and on the use of companion crops in the management of key pests & diseases of tropical crops, providing important information for transitioning organic farmers and other sustainable producers.

In Puerto Rico, heat stress, inadequate adaptation of breeds to tropical climates, elevated costs of production (especially feed imports), poor forage management and utilization, low genetic potential, and imports of animal products negatively impact livestock production. Research efforts have been focusing on seeking improvement in the biological efficiency of livestock productive, and reproductive performance, (dairy cattle, beef cattle and sheep production), economic returns to the producers, and practices that promote extreme weather resilience. Milk production continues as the major animal science enterprise on the island and heat tolerant dairy cattle that can tolerate warmer climates and perform more efficiently demand prompt attention. A slick hair gene appears to be an adaptation of cattle to heat stress. Already slick dairy and beef cattle grown in Puerto Rico have been characterized using commercially available tools for genetic selection and a state-of-the-art animal reproduction lab has been established. Experiments to evaluate the effect of using an automated milk feeder to deliver an accelerated growth feeding protocol on the weight gain and future milk yield in slick and wild-type Holstein calves have been conducted. Research efforts to enhance reproductive performance of slick hair Holstein cows also include the evaluation of fertility, embryo characterization, reproductive endocrinology and liver physiology. For beef production research has been focused on reproductive performance, cow productivity, and temperament assessment of purebred senepol and Angus x Senepol cows. Likewise, trials on young bull supplementation and fertility, yield, quality and persistence of tropical improved grasses for grazing have been conducted. Trials evaluating the use of post-extraction algae residue as a possible feedstuff were concluded, offering producers information on the utilization of micro-algae as a potential protein supplement for cattle. The small ruminant industry (sheep and goats) is still growing, and producers organizing and creating cooperatives to develop more competitive agricultural enterprises. Research efforts to improve reproduction and profitability of criollo ewes in a tropical environment are the main objective of reproductive performance trials. Experiments on feeding strategies genetics, and castration on performance, carcass, and retail cuts yield, and meat quality of criollo and crossbreeds lambs are also under progress.

Following the significant decline in Puerto Rico's bee population after Hurricane María in 2017, the need for sustainable pollinator management strategies became urgent. The Honeybee Research and Extension Program was developed in FY 2023 to address this issue by bolstering the bee population, ensuring sustained pollination of natural ecosystems and agricultural plants. Targeting individuals interested in honey production, beekeepers, and bee removers, we intend to provide training to effectively manage bee colonies, enhance honey production, and address beekeeping challenges. We anticipate reporting significant progress in the upcoming reporting period.

The Urban Poultry Farming program was also created on FY 2023 to address Puerto Rico's food security concerns by empowering students from elementary to high school to establish their own backyard chicken farms. By training students in chicken farming from hatching to laying hens, the program not only promotes the audience to produce a sustainable source of fresh eggs but also instills essential skills in animal husbandry and food production. During the

first phase of the program, a total of 357 students benefited from the educational activities of the program, focusing on learning how to hatch chicken eggs. Collaboration with a local egg producer resulted in the donation of 70 fertilized eggs distributed among 4H school groups, achieving a hatch rate of 44 to 75%. Students expressed interest in raising laying hens, with some already having chickens and seeking advice on embryonic development. Positive feedback from students highlighted their enthusiasm for agriculture and newfound knowledge about egg incubation.

Significant progress was achieved through the Enhancing Crop Health to Maximize Plant Production PRAES program. More than 200 crop producers have benefitted from the educational materials and on-field interventions, contributing to a boost in crop production in Puerto Rico. Educational resources have been shared with other PRAES initiatives, including 4H, master gardeners, and community resource development, fostering an integrated approach. The period saw the initiation of nine new vegetable farms, an expansion in local product output from 83 growers, and the adoption of sustainable practices by 10 growers. Additionally, our partnership with the PRAEX seed initiative, "Seeds for my Land," facilitated the establishment of new bean farms spanning over 15 acres, engaging 27 growers. These efforts have positively impacted the vegetable industry, enhancing farmers' resilience to adverse weather conditions.

Critical Issue: Positive youth development

In Puerto Rico there is a crucial need to adapt and enhance spaces within PRAES 4-H program to better serve the blind and deaf communities, ensuring full inclusivity and accessibility. Over the past four years, significant efforts have been dedicated to developing resources that facilitate the participation of deaf youth in 4-H activities. Building on this momentum, we are expanding our focus to include the blind youth, with a commitment to creating a supportive environment for their engagement. Our primary goal is to ensure 4-H of Puerto Rico embodies a welcoming, inclusive, and diverse space where every young individual feels a sense of belonging and empowerment. Through continuous improvement and dedicated initiatives, this initiative aims to make 4-H a model for inclusive youth development program. In addition, there is significant number of children and youth that live below the poverty level, being PR the jurisdiction within the US with the highest percent of youth that live in poverty. In 2021, the island had 55% of children and youth aged 0 to 17 living in poverty, representing 325 thousand kids and adolescents, and 82% of them participate in nutritional assistance programs. Among youth aged 16 to 20, 23% are neither studying nor working, living in poverty, and facing the risk of homelessness. Furthermore, youth aged 16 to 21 in college experience a lack of economic resources to support their studies and sustain this stage of life.

Through a series of engaging seminars, conferences, and interactive workshops, we immersed 4-H youth in concepts of diversity, equity, and inclusion (DEI). These activities served as a platform for extension educators, volunteers, and 4-H members, equipping them with opportunities to initiate meaningful dialogues with diverse communities. This approach not only raised awareness within the 4-H program and the University of Puerto Rico about the unique needs of these communities but also fostered a deeper understanding and appreciation of diversity among participants, enriching the 4-H experience with valuable lessons in empathy and social awareness.

The program also implemented additional activities designed to enlighten children and teens about DEI principles through afterschool activities, virtual courses, and in-person sessions. These efforts went beyond merely imparting knowledge; they aimed to foster an engaging environment that motivates young individuals to explore strategies for overcoming barriers to accessing key services such as education, social support, and healthcare. This initiative was particularly focused on addressing challenges faced by those with physical impairments or who encounter discriminatory practices, thereby promoting a more inclusive and equitable community.

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- A team from Puerto Rico, comprising two 4-H youth leaders, a volunteer, and an extension educator, participated in the True Leaders Equity Institute (TLEI). During the TLEI, youth leaders unveiled an action plan aimed at creating or enhancing existing spaces within Puerto Rico's 4-H program to better accommodate the blind and deaf communities. Their plan also proposed the development of educational resources designed to support inclusive activities for these communities within 4-H. To support their participation and acknowledgment of their initiative, the 4-H leaders were awarded scholarships to attend TLEI.
- Following their completion of a certified American Sign Language (ASL) course, a team of four 4-H members identified and chose to support a deaf community in their daily activities. A deaf family collaborated with the team, actively participating, and sharing insights across various settings to highlight the specific needs and challenges faced by the deaf community.
- A college student from the 4-H OYE program designed and delivered three online workshops titled "*En señas*," enabling 35 participants to acquire basic sign language communication skills. In recognition of his exceptional efforts to promote sign language experiences within 4-H in Puerto Rico, he was invited to serve as a workshop facilitator at the 2023 True Leaders Equity Institute.

4-H Equity Challenge

- Twenty 4-H participants actively engaged in and successfully completed Equity Challenges, where they delved into reflections and collaborative efforts addressing inequities, prejudices, and discriminatory practices across four major areas: STEM, Photography, Writing, and Scenic Arts.
- Six youth leaders have taken on the role of leaders and mentors, guiding their peers through the 4-H Equity Challenge, while four extension educators contributed as mentors. This initiative, crafted by the DEI team and backed by the National 4-H Council, has provided 4-H members with opportunities to introduce innovative 4-H projects.

Tackling poverty and food insecurity requires significant structural and political interventions. Our key initiatives involved active participation from 4-H teen leaders and members collaborating with community organizations, university units/campuses, and 4-H clubs across the island. PRAES Extension Educators played a vital role in mentoring, facilitating, and educating 4-H youth leaders and college students in organizing community workshops and developing educational materials on food preservation.

4-H ACCESO program

The ACCESO initiative provided a platform for reflecting on and addressing inequities that contribute to homelessness, a growing concern among youth and college students in the past decade. Educational activities centered on fostering positive youth development, nurturing critical thinking skills, and creating spaces for analyzing how inequities and exclusions impact both youth and society. Additionally, collegiate volunteer students and 4-H youth delivered training to 4-H members in food preservation and creation and maintenance of food gardens to increase fresh food access.

- Through a guidance activity in the PRAES demonstration garden, 300 Family, Career, and Community Leaders of America students acquired knowledge about the production of food at home or in schools by establishing food gardens.
- 4-H leaders and PRAES staff established a college alliance to utilize the culinary laboratory of the hotel school at UPR Carolina campus to prepare 4-H students in food preservation.
- Six 4-H youth leaders completed a food preservation course and designed a video series to educate college students.
- Two hundred youth and adults obtained the opportunity to receive training from PRAES extensionists and 4-H teen leaders about food access (from farm to table) at the UPR-Carolina Campus. The participants received educational materials, seeds, and plants to kickstart their own gardens.
- Students involved in the ACCESO program, guided by their Extension mentors, submitted a community action plan to the National 4-H Council and successfully secured funding to implement their proposed initiatives.

Route for Healthy Living:

- Our healthy habits initiatives, sponsored by the National 4-H Council and Walmart Foundation celebrated 13 years promoting healthy lifestyles on the island.
- Two college students participating in the Healthy Living project shared with seventy-four 4-H teen teachers in 2023 how the project helped them select their academic careers.
- A total of 1,221 participants completed non-formal education in healthy lifestyles.
- 74 youth leaders were trained to broaden the healthy living knowledge in their communities.
- Three youth leaders from Ruta represented Puerto Rico in 4-H Ignite 2023.
- Healthy Lifestyles and Food Systems
- A total of 3,274 participants gained knowledge about food systems and food security, with 1,486 receiving in-person training at a PRAES demonstrative garden located in the Botanical Garden in Río Piedras

Merit and Scientific Peer Review Process

Updates

PRAEXS

As explained in our 2024 Plan of Work, not the relevant one for this 2023 annual report but reflecting adjustments already in process during 2023:

No significant changes are expected to occur in the PRAEXS merit review process, but minor adjustments are being made. Part of our Hatch funds will continue to be allocated to competitive project grants. Some funds will also be earmarked as three-year seed grants for recently recruited faculty wishing to advance our research agenda. The competitive funded proposals will be selected based on the year's revised priorities published in our annual call for proposals. During this POWs period, requested proposals are expected to contribute to the “Regeneration of agri-food production in a sustainable way in the face of climate change and demographic challenges”, a broad topic that harbors many of our stakeholders pressing concerns. Earmarked seed grants could also include emerging rural or local food system research areas that need to be developed in Puerto Rico. All the proposals will be submitted to the Assistant Dean for Research with the endorsement of Department Heads, and their scientific merit will be evaluated by internal and external peer reviewers. Final decisions will be made by a panel of College of Agricultural Sciences (CAS) administrators with representation from program coordinators, commodity area leaders and non-CAS evaluators.

None for PRAES

Stakeholder Input

Actions to seek stakeholder input that encouraged their participation with a brief explanation

None for PRAEXS.

None for PRAES

Methods to identify individuals and groups and brief explanation

In addition to the methods described in our POW, PRAEXS commodity and program leaders and associated faculty have created Facebook pages to disseminate activities and relevant commodity information. Interested stakeholders making contact through this and other social networks are also invited to attend commodity meetings where needs and priorities are assessed.

None for PRAES

Methods for collecting stakeholder input and brief explanation

Several PRAEXS commodity and program leaders have conducted more formal surveys of stakeholders needs, priorities and concerns, complementing in this manner the information collected through personal communications and evaluation forms distributed at the end of meetings and workshops, described in the relevant approved POW.

None for PRAES

A statement of how the input will be considered and brief explanation of what you learned from your stakeholders

Following recommendations from our stakeholders on how to improve the performance of our programs, over the past year PRAEXS began an evaluation process that included a reassessment of the way we structure our research and gather input to establish our priorities. A new format for requesting Hatch competitive proposals has already been adopted, which includes a broader list of priorities covering previously neglected issues and topics newly identified by stakeholders. The internal planning of activities by commodity leaders and critical issues contacts have also been re-examined to facilitate better coordination with PRAES and other relevant organizations agendas.

In addition, as described in our POW, eight new Hatch projects aligned with priorities identified by stakeholders were initiated last year in areas such as rural health, vegetable production under high tunnels, formulations for value added fruit products, and low-cost sustainable practices for the production of food crops, among others. Stakeholders input was also critical for justifying the recruitment of new faculty appointments in several previously underserved areas such as agroecology, certain animal science specialties and agricultural economics.

PRAES continues to gather, assess, and disseminate stakeholder needs (to Extensionists) through the CASEA committee, comprised of the Director of the Planning and Evaluation Office, the Extension Planning and Evaluator Specialist, and the Community Economy and Sustainable Development Program Leader. A graduated student, specialized in statistics, uses the data collected to generate descriptive statistics to better address the stakeholder input. The committee continues to distribute the results, along with recommendations, to all the Extension Personnel to better address the needs, employing an integration approach among the four Extension Programmatic Areas.

Highlighted Results by Project or Program

Critical Issue

Community, economy & sustainable development

Program

	Results	Organization	Initiator
Community self-management, economic development, and volunteers' resilient projects during critical times.	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Project

	Results	Organization	Project Director
Consumer attitudes and behavior towards differentiated products in Puerto Rico: An assessment of text, labels and quick response (QR) codes	1	University of Puerto Rico Mayaguez Campus	Hector Tavarez

Project

	Results	Organization	Project Director
Evaluation of Alternative Coffee Harvesting Methods for Puerto Rico	1	University of Puerto Rico Mayaguez Campus	Francisco M. Monroig

Critical Issue

Extreme weather, environment, natural resources, and sustainable energy

Project

	Results	Organization	Project Director
Agroecological Practices Adapted to Extreme Weather Conditions	1	University of Puerto Rico Mayaguez Campus	Jose Dumas

Project

	Results	Organization	Project Director
Identification and distribution of potentially toxic contaminants in Puerto Rican soils	1	University of Puerto Rico Mayaguez Campus	Daniel Bair

Project

	Results	Organization	Project Director
Low Cost and Locally Available Inputs and Sustainable Practices for Increasing the Resiliency and Sustainability of Food Crops	1	University of Puerto Rico Mayaguez Campus	Christian Rivera-Goyco

Program

	Results	Organization	Initiator
Natural resource protection amid extreme weather and natural disasters	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Project

	Results	Organization	Project Director
Soil quality assessment among soil orders and ecological zones in Puerto Rico	1	University of Puerto Rico Mayaguez Campus	Miguel Munoz

Critical Issue

Family well-being

Program

	Results	Organization	Initiator
Food Security	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Program

	Results	Organization	Initiator
Health and Well-being	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Critical Issue

Food safety, science and technology

Project

	Results	Organization	Project Director
Development of High-Quality Value-Added Products Made from Coffee	1	University of Puerto Rico Mayaguez Campus	Javier Huertas

Project

	Results	Organization	Project Director
Enhancing Microbial Food Safety by Risk Analysis	1	University of Puerto Rico Mayaguez Campus	Maria Plaza

Project

	Results	Organization	Project Director
Manufacture of Yam (Dioscorea rotundata) flour as a possible ingredient in the preparation of pasta, bread, and extruded products	1	University of Puerto Rico Mayaguez Campus	Rosa Chavez-Jauregui

Critical Issue

Food security, plant & animal systems

Project

	Results	Organization	Project Director
Adaptability and Performance of Specialty Tomatoes and Asian Vegetable Varieties in Different Production Systems in Puerto Rico with Market Opportunities	1	University of Puerto Rico Mayaguez Campus	Ermita Hernandez-Heredia

Project

	Results	Organization	Project Director
Breeding Phaseolus Beans for Resilience, Sustainable Production, and Enhanced Nutritional Value	1	University of Puerto Rico Mayaguez Campus	Elva Consuelo Estevez De Jensen

Project

	Results	Organization	Project Director
Cover Crops for Sustainable Southern Agroecosystems	1	University of Puerto Rico Mayaguez Campus	Elide Valencia

Project

	Results	Organization	Project Director
Design and evaluation of protocols for early detection and management of plant pathogens	1	University of Puerto Rico Mayaguez Campus	Merari Feliciano

Project Closing Out (end date 09/30/2024)

	Results	Organization	Project Director
Effects of using an automated milk feeder to deliver an accelerated growth feeding protocol on the weight gain and future milk yield in slick and wild-type Holsteins calves	1	University of Puerto Rico Mayaguez Campus	GUILLERMO ORTIZ

Program

	Results	Organization	Initiator
Enhancing Crop Health to Maximize Plant Production	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Project

	Results	Organization	Project Director
Exploring the use of Post-Extraction Algae Residue (PEAR) as a protein supplement for beef cattle in Puerto Rico	1	University of Puerto Rico Mayaguez Campus	Katherine Domenech-Perez

Project

	Results	Organization	Project Director
Fertility and embryo characterization of slick hair Holstein cattle	1	University of Puerto Rico Mayaguez Campus	Veronica Negron

Project

	Results	Organization	Project Director
Implementation of novel reproductive biotechnologies and genomics for the multiplication and commercialization of genetically superior Slick cattle	1	University of Puerto Rico Mayaguez Campus	Melvin Pagan-Morales

Project

	Results	Organization	Project Director
Improvement of reproduction and profitability of criollo ewes in a tropical environment	1	University of Puerto Rico Mayaguez Campus	John Fernandez-VanCleve

Project

	Results	Organization	Project Director
Population Outburst of Stem borers in Tropical Fruits in the South of Puerto Rico	1	University of Puerto Rico Mayaguez Campus	Irma Cabrera

Program

	Results	Organization	Initiator
Urban Poultry Farming	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Project

	Results	Organization	Project Director
Use of companion crops in the management of invasive insects & other key pests & diseases of tropical crops: Research & demonstration project for transitioning organic farmers	1	University of Puerto Rico Mayaguez Campus	Rosa A. Franqui-Rivera

Critical Issue

Positive youth development

Program Closing Out (end date 09/30/2025)

	Results	Organization	Initiator
Opportunities for youth in equity (OYE)	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo

Program

	Results	Organization	Initiator	
Teens leading the change for community wellness.	1	University of Puerto Rico Mayaguez Campus	Jaime Curbelo	

Appendix

Research Projects

Extension Programs

Other Projects / Programs