

Enhancing Climate Literacy and Climate-Informed Management to Strengthen Agriculture and Forestry Sectors in the Face of a Changing Climate: Insights from the Climate-Smart Caribbean Workshops

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Adaptation;
Agriculture;
Climate services;
Vulnerability

Climate-Smart Caribbean Workshops

What: The USDA Caribbean Climate Hub has led six collaborative workshops designed to help agriculture and forestry producers, managers, and advisors learn about climate change tendencies and support climate-informed planning actions in Puerto Rico. The effectiveness of the workshops was assessed by examining participant's evaluations.

When: 17 March 2023–21 March 2024

Where: Utuado, Camuy, Juana Díaz, Maricao, Lajas, and Arecibo, Puerto Rico

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1. Introduction

The agricultural and forestry sectors of the Caribbean are increasingly vulnerable to the challenges posed by climate change. Less predictable rainfall, more intense extreme climate events, and more days of extreme heat threaten crop and livestock productivity intensify pest and disease pressures, degrade soil health, and lead to significant social and economic challenges (Méndez-Lazaro et al. 2023; Gould et al. 2018). Although climate scenarios can help assess the detrimental implications of climate change in the Caribbean, substantial gaps persist in public knowledge regarding climate change, its regional effects, and potential adaptation mechanisms (Méndez-Lazaro et al. 2023).

Delivery of climate services can be thought of as an iterative, adaptive process where service providers understand needs, deliver services, and assess the outcomes of that delivery, informing a new round of development and delivery. In Puerto Rico, we understand that 92% of the population is aware of the concept of climate change, and it is among the countries and territories most worried about its impacts (Leiserowitz et al. 2023). Nonetheless, recent climate change reports indicate there is a lack of understanding of other basic climate literacy concepts like greenhouse gases, adaptation, and mitigation [Méndez-Lazaro et al. 2023; Departamento de Recursos Naturales y Ambientales (DRNA) 2018]. This knowledge gap implies that there is room for additional education and outreach efforts to raise climate literacy and promote climate-smart decision-making.

Agriculture and forestry service providers, farmers, and land managers have expressed the need for actionable, sector-specific information and guidance on adaptation and mitigation strategies relevant to where they live and work (McGinley et al. 2022). For instance, studies have found that agricultural and forestry advisors working in the public sector in Puerto Rico and the U.S. Virgin Islands feel they would be better equipped to support producers and landowners if they had access to tailored information on climate change impacts in the region (Álvarez-Berríos et al. 2021; McGinley et al. 2022; Wiener et al. 2020). They also indicated that workshops focused on disaster recovery and climate preparedness would be useful. In the case of Puerto Rican farmers, while the majority recognize global climate change and express a desire to adapt their agricultural practices for future extreme events, they frequently are constrained financially, technologically, and otherwise in fully implementing the necessary strategies. The challenges include knowledge gaps, limited resources, and challenges in accessing government resources and support (Rodríguez-Cruz and Niles 2021; McGinley et al. 2022).

In response to the need for actionable information, the USDA Caribbean Climate Hub developed and delivered a series of climate change workshops for farmers and forest managers (known as climate-smart workshops or OneUSDA workshops), focusing on the demonstrated need for education in climate adaptation and mitigation. Developed in collaboration with the USDA agency representatives and extension staff, these workshops highlighted regional examples, key tools, and educational resources to support sustainable land management in

the context of a changing climate. By focusing on increasing access to science-based climate information, these workshops aim to better equip farmers, ranchers, and forest land managers to understand the causes and long-term consequences of climate change. Ultimately, the goal is to enhance support for and implementation of adaptation and mitigation practices on agricultural and forest lands via the climate-smart workshops held in strategic locations in Puerto Rico. Here, we present an overview of the evaluation outcomes of the first set of climate-smart workshops.

2. Workshop activities

From March 2023 to March 2024, the Caribbean Climate Hub and its partners organized six in-person climate-smart workshops, aiming to increase climate literacy among farmers and landowners (Table 1). Several factors distinguish climate-smart workshops from other types of training, classes, and webinars typically offered by climate service organizations. The workshops included representation from a suite of USDA agency staff. They provided dedicated spaces for participants to interact with partners and diverse organizations, offering peer-to-peer learning opportunities and serving as a one-stop shop for multiple resources (Fig. 1). Each workshop is often centered around a specific geographical area, leading to the recruitment of participants from particular agricultural regions. The workshops target underrepresented groups including women, veterans, and beginning farmers. In total, 24 partner organizations participated in the workshops, including agricultural or forestry projects (41%), federal

TABLE 1. Descriptive information for the six climate-smart workshops held in various municipalities across Puerto Rico. Partners name and acronyms: Federal agencies: Natural Resources Conservation Service (NRCS), Forest Service State, Private, and Tribal Forestry (SPTF), APHIS-Plant Protection and Quarantine (APHIS-PPQ), APHIS-Veterinary Services (APHIS-VS), Rural Development (RD), Food and Nutrition Service (FNS), Tropical Agriculture Research Station (TARS), and NOAA National Weather Service (NWS) in San Juan. University partners: UPR Agricultural Extension Services (UPR Ag Extension). NGOs: Puerto Rico Association of Soil Conservation Districts (PRASCD), Caribbean Regenerative Community Development (CRCD) Puerto Rico, Cafiesencia, and ProCafé. Agricultural and forestry projects: Puentes Naturales, Microfinca, Atabey Farm, Tai Hay Farm, AA Ranch, Finca Terruño, Semila/Cacao 360, Puerto Rico Bean to Bar, Finca Cruz, and Bosque Caos. International organizations: Tropical Agricultural Research and Teaching Center (CATIE).

Date	Municipality	Venue	Partners	Focus	Evaluation participants	Estimated participants in the event
17 Mar 2023	Utuado	UPR, Utuado (18.2547, -66.7211)	PRASCD, RD, NRCS, SPTF, APHIS-PPQ, APHIS-VS, and Puentes Naturales	Coffee	14	30
14 Apr 2023	Camuy	Centro Comunal Yeguada (18.4714, -66.8995)	PRASCD, NRCS, SPTF, APHIS-PPQ, FNS, and La Microfinca	Small-scale farming	13	30
12 May 2023	Juana Díaz	Agricultural Experimental Station (18.0394, -66.5252)	PRASCD, NRCS, SPTF, APHIS-PPQ, SJNWS, UPR Ag. Extension, and Atabey Farm	Coastal farming, crops, and fruit trees	22	39
9 Jun 2023	Maricao	Fundación Bucarabón (18.1764, -66.9140)	PRASCD, NRCS, SPTF, APHIS-PPQ, UPR Ag. Extension, CRCD, ProCafé, Cafiesencia, Finca Cruz, and Bosque Caos	Coffee and forestry	35	>40
11 Aug 2023	Lajas	Agricultural Experimental Station (18.0324, -67.074)	PRASCD, NRCS, SPTF, APHIS-PPQ, UPR Ag. Extension, CRCD, Tai Hay Farm, and AA Ranch	Livestock and small ruminant	23	42
21 Mar 2024	Arecibo	Inter American University (18.4760, -66.7594)	PRASCD, NRCS, SPTF, APHIS-PPQ, UPR Ag. Extension, CRCD, CATIE, TARS, Finca Terruño, Semila/Cacao360, and Puerto Rico Bean to Bar	Cacao	45	55
Total					152	236
Response rates					64%	



FIG. 1. Workshop components include providing information on climate change science, future scenarios, and regional climate indicators; peer-to-peer learning opportunities with regional case studies; panel discussions on climate-smart practices with agencies and experts; and information tables with partners from USDA, Cooperative Extension, Conservation Districts, Climate Smart Commodity Partners, and nongovernmental organizations.

agencies (33%), nongovernmental organizations (NGOs) (16%), international organizations (4%), and university partners (4%) (Table 1).

The workshops, typically lasting half a day, consist of several key components:

- 1) **Presentation on climate change science:** This includes an overview of climate change basics, future scenarios, and relevant indicators for Puerto Rico.
- 2) **Peer-to-peer learning and case studies:** Selected growers, ranchers, or forest managers present on their challenges with climate impacts and adaptation practices implemented to increase resilience. These sessions allow attendees to learn firsthand about the challenges of managing and operating farms under climate stressors, specific to the region and the strategies being employed to cope with these challenges. A postworkshop video of the peer-to-peer case study is produced and made available online for future reference.
- 3) **Discussion panel with USDA, extension personnel, and other partners:** A panel discussion featuring key USDA personnel and representatives from agricultural extensions and other partners is conducted (Table 1). The panel focuses on climate-smart practices promoted by USDA and other available resources, such as incentives for alternative energy. This includes a Q&A session where participants can ask questions about climate-smart practices, programs, and aids offered by the agencies and experts.
- 4) **Information booths:** The workshops also feature information booths staffed by federal and local agencies, NGOs, and agricultural and forestry organizations. These booths provide networking opportunities, showcase tools, and offer information on assistance programs and other resources available through entities like Rural Development (RD), Natural Resources Conservation Service (NRCS), Animal and Plant Health Inspection Service (APHIS), Forest Service State, Private, and Tribal Forestry, Food and Nutrition Service (FNS), and Climate-Smart Commodities Partners.

3. Workshops evaluations

We assessed the effectiveness of the workshops and the climate awareness gained through formal participant feedback. The principal source of feedback is a written survey that we collect following each workshop. The evaluations allow us to understand 1) whether participants have increased their level of climate awareness, 2) which training elements were effective, and 3) how participants plan to use information going forward. The survey included ranking questions using a Likert scale of 1–5, open-ended questions, and comment sections. Using a retrospective post-then-pre design, participants were asked to rate their postworkshop knowledge, skills, or attitudes compared to their preworkshop assessment (following Schmitt et al. 2021). The analysis of the survey responses included descriptive statistical analysis and dependent, paired sample *t*-test statistics. The Institutional Review Board, University of Puerto Rico (UPR), protocol 2022080007, approved the survey instrument.

4. Workshop outcomes

In total, 236 individuals participated in the climate-smart workshops, ranging from 13 to 45 attendees. From these, 152 completed the survey, for a response rate of 64%. Based on the information registration collected before the workshop, the predominant agricultural products of the attendees included plantains, coffee, fruit trees, cacao, vegetables, beef cattle, and small ruminants, from a diversity of 14 agricultural products reported. More than 50% of attendees mentioned they keep forests on their lands or farms. Around 70% responded that their farms or lands have been affected by climate change.

The workshops mainly attracted beginning farmers who had been cultivating their land for less than a decade (Table 2). Women farmers (15.8%) and agroecology practitioners (13.6%) are also well represented in our workshops. Educators (16.2%) comprised a significant proportion of the participants. This was an unexpected and welcomed result of the workshops, indicating these spaces are serving a dual purpose: direct knowledge exchange and train-the-trainer sessions. Young farmers or ranchers under 30 years of age and the U.S. Military Veterans were also represented, both groups comprising 6.5% of the participants.

The evaluation results reflect participants' positive perceptions of the workshop's effectiveness in meeting its objectives. The evaluation component focusing on engagement of the workshop received outstanding scores, with an average of 5 rating (strongly agreed), regarding the quality of the information presented, the overall venue quality, and the instructors' performance. When asked if they would recommend the workshop to peers and coworkers, attendees also strongly agreed (Table 3).

TABLE 2. Groups represented in the workshops.

Groups	Percentage mentioned (<i>n</i> = 228) (%)
Educator	16.2
Beginning farmer or rancher (1–10 years of operation)	15.8
Women farmer/women-owned farm business	15.8
Agroecological farmer	13.6
Technical support	10.5
Conventional agriculture	10.1
Student	5.7
Young farmer or rancher (under 30 years of age)	3.9
U.S. Military Veteran	2.6
Other	5.7

TABLE 3. Average evaluation scores ($n = 151$) of different evaluation components.

Component	Question	Score	SD
Was the training engaging? (strongly disagree 1, strongly agree 5)	The goals of the activity were made clear at the beginning.	5	0.87
	The venue was a comfortable environment for learning.	5	0.92
	I was able to get help from the instructors when I needed it.	5	0.93
	The presentation, handouts, and other materials given helped me understand the concepts.	5	0.84
	The instructors were able to explain concepts using language that I could easily understand.	5	0.81
	I would recommend this workshop to my peers/coworkers.	5	0.83
Will the participants be using what they learn on the workshop? (unlikely 1, likely 5)	How likely are you to implement the topics discussed today, in your work?	5	0.75
	How likely are you to apply the process and practices discussed today to future projects/plans?	5	0.61
	How likely are you to share what you learned at this training with other partners and colleagues in your organization?	5	0.57
	How likely are you to share what you learned at this training with community members?	5	0.72

The retrospective post-then-pre self-assessment for level of knowledge results indicate that a majority of participants (>70%) reported gains in knowledge about climate change actions, available resources, adaptation and mitigation practices, and trends and projections. The responses to the level of knowledge before and after the workshops indicate a consistent increase in literacy, with the highest level of increase attributed to understanding the potential local impacts of climate change in the lands they manage (a significant increase of 1.19) (Fig. 2). The results measuring participant' understanding of the actions and resources available for them to address climate change in their region was not as extensive (0.99 increase), underscoring the need for future trainings.

Surprisingly, more than 90% of respondents indicate that they are very likely or likely to use the gained knowledge in their future projects, at work, or in their community. This was also evidenced by average scores of 5 (strongly agreed) in the set of questions regarding the intention to use and share the gained literacy going forward (Table 3). Participants shared

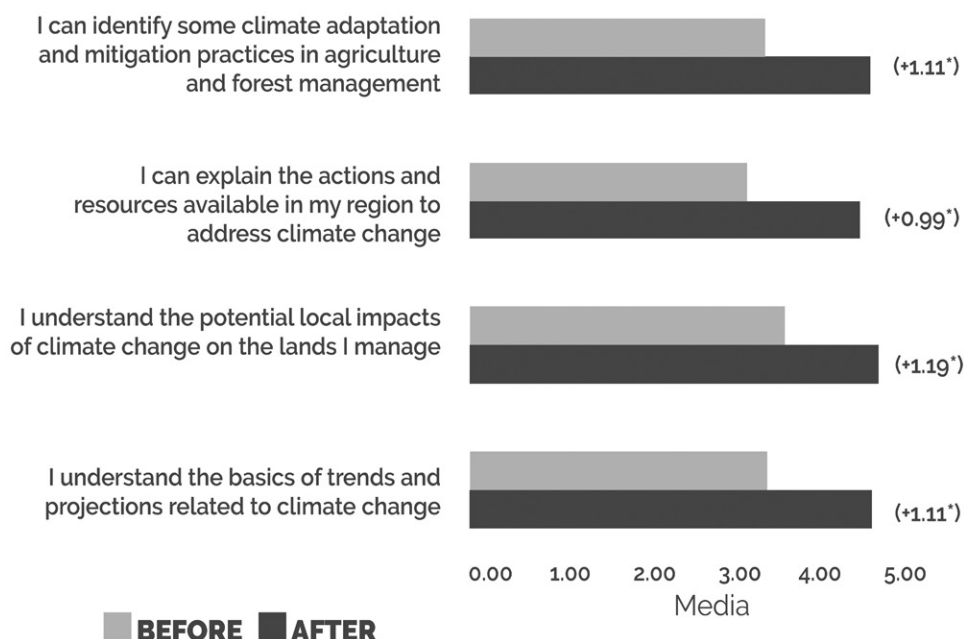


FIG. 2. Summary of retrospective pre-post self-assessment of respondents' level of knowledge ($n = 142$) indicates significant learning activity. Parentheses indicate change between pre- and postworkshop, and * indicates $p < 0.0001$ for two-tailed significance t test. Likert scale 1 = none; 2 = a little; 3 = some aspects; 4 = very knowledgeable; and 5 = ready to present.

TABLE 4. Challenges of integrating climate change adaptation into your work.

Challenges	Percentage mentioned (<i>n</i> = 260) (%)
All of the above	66
Administrative resources (e.g., staff, time, equipment)	58
Technical or detailed guidance on how to implement practices	53
Economic limitations	52
Support within your organization from leadership/supervisors	23
None	8

challenges for integrating the gained knowledge into their work, naming economic limitations, lack of administrative resources, such as staff and time, equipment, and technical or detailed guidance on how to implement practices as the top three challenges. Most respondents indicate that the challenges are a combination of the named factors (Table 4).

A postworkshop video of each peer-to-peer case study is produced and made available online for sharing regionally relevant climate adaptation practices more broadly. The objective of these videos is to provide information to the agricultural community on adaptation and sustainable management practices that help reduce the risks and vulnerabilities of climate change in agricultural production or forest management. These recordings are available as a series covering different regionally important sectors. Each of the five videos, produced in Spanish and English, present a grower responding to these questions:

- What climate change–related effects, if any, have been most challenging for your farm/operation?
- How have you dealt with these challenges? What practices have proven most useful as adaptation measures?
- Have you worked with technical advisors from USDA or other entities?
- Why do you think it is important to implement climate adaptation/conservation practices on farms/operations?
- What recommendations can you give to other producers facing similar challenges?

To date, the videos have received 2764 (Spanish) and 1443 (English) views (Table 5).

TABLE 5. Study cases videos available, sharing regionally relevant climate adaptation practices (links and date published).

Focus	Videos	Date published	View counts (14 Apr 25)
Small-scale farming	La Microfinca (Spanish)	22 Aug 23	798
	La Microfinca (English)		432
Coastal farming, crops, and fruit trees	Finca Atabey (Spanish)	25 Sep 23	377
	Finca Atabey (English)		296
Coffee and forestry	Finca Cruz (Spanish)	26 Oct 23	106
	Finca Cruz (English)		212
Forestry	Bosque Caos (Spanish)	15 Dec 23	407
	Bosque Caos (English)		201
Livestock and small ruminant	Rancho AA (Spanish)	12 Jan 24	1076
	Rancho AA (English)		302
Total views			4207

5. Concluding remarks and next steps

Challenges associated with climate change are driving numerous efforts aimed at enhancing climate literacy and advancing solutions for climate adaptation. While there is evidence that these efforts can result in improved climate knowledge and land management, measuring the extent of these implemented changes and their effect on adaptation and mitigation is often difficult. The structured feedback from participants' evaluations of the first six climate-smart Caribbean workshops suggests the discussions resulted in improved climate knowledge for most of the climate-smart workshop participants and interest in the implementation of these learnings.

We identified several factors that contributed to the success of the workshops: 1) Presentations of case studies, panels, and information tables were tailored to the region, focusing on the agricultural crops and activities of priority, bridging organizational divides, and recognizing common challenges; 2) The introduction and welcoming included an overview of the participants' profile, highlighting main crops, forest cover, climate change impacts, and climate-smart practices in use as a way to foster communalities and the opportunity to learn from each other; 3) Preparatory meetings with peer-to-peer presenters were held to answer questions, ensure preparedness, and adjust the presentations where necessary; 4) A good balance between active time and passive time was achieved, making space for learning and interaction at the information booths and within each other. These findings also identified areas for improvement and can inform future workshop planning to enhance the delivery of climate literacy programs, better serving farmers and landowners in the Caribbean region.

Next steps were as follows:

- broaden the scope of the workshop model to include other topics and international presenters and audiences;
- include case studies from the U.S. Virgin Islands;
- continue promoting the farm-to-farm videos from the case studies; and
- improve participation from underrepresented groups such as veterans and beginning farmers.

Through these expanded efforts and collaborations, our goal is to enhance the region's ability to adapt and mitigate climate change, build climate change resilience, reduce vulnerability to extreme events, and assist in mitigation efforts.

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Data availability statement. The data presented in this study may be available on request from the authors. The evaluation data are not publicly available due to privacy reasons.

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