BAMS
Meeting Summary

Fostering Knowledge Exchange and Collaboration among Drought-Related Initiatives in the Caribbean

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First Annual Meeting of the Caribbean Drought Learning Network (CDLN)

What: Participants of the Caribbean Drought Learning Network's first annual meeting discussed issues surrounding droughts in this region, including the need to increase awareness of drought-related initiatives in Puerto Rico and the U.S. Virgin Islands and the promotion of peer-to-peer learning pertaining to the latest in drought research and communications.

When: 8–9 September 2022

Where: Online

KEYWORDS: Drought; Dust or dust storms; Precipitation; Soil moisture; Soil temperature; Probabilistic Quantitative Precipitation Forecasting (PQPF)

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Droughts are major climate events that have strong negative effects on water resources for both natural and human systems worldwide. In the Caribbean, droughts have affected agricultural production and local economies and have diminished the quality of life for the general population (Álvarez-Berríos et al. 2018). Better monitoring, forecasting, and planning efforts could certainly lead to improved ways of coping with the impacts of droughts in this region.

Strong negative effects of droughts in Puerto Rico (PR) and the U.S. Virgin Islands (USVI) stress the need to build resilience at local and regional levels, but reaching this goal has had its obstacles. For instance, drought-related initiatives have existed in the region but have often been siloed by agencies or remained unknown to other relevant entities. There is also a need to foster and support the generation and dissemination of tailored drought information that is temporally and spatially relevant to regional drought decision-makers.

A pivotal step to begin addressing the disconnect among drought professionals and lack of critical drought information is to strengthen collaboration and communication among researchers, managers, and local stakeholders. Drought Learning Networks (DLN), initially established by key climate providers in the southwestern United States, provide valuable frameworks to achieve these goals as they promote peer-to-peer knowledge exchange between climate service providers and resource managers (Elias et al. 2020). Realizing the potential benefits of an analogous network in the Caribbean, members of the USDA Caribbean Climate Hub (CCH) proposed the creation of a Caribbean Drought Learning Network (CDLN).

An exploratory meeting to assess interest in establishing a Caribbean Drought Learning Network on 10 June 2021 served as the starting point for this initiative (USDA Caribbean Climate Hub 2021). The event was followed up by a "kickoff" meeting on 14 October 2021 to officially launch the network. These virtual events were attended by local agencies, researchers, and organizations from Puerto Rico, the U.S. Virgin Islands, and other partners in the region. The meetings served to identify key issues that the network could address, identify interested partners, and jumpstart network initiatives, including the establishment of four focal working groups: 1) Impact Reporting and Citizen Science; 2) Drought Prediction, Monitoring, and Research; 3) Drought Communication and Outreach; and 4) Drought Resilience in Agriculture and Forestry.

The present summary provides an overview of the first Caribbean Drought Learning Network Annual Meeting, hosted by the USDA Caribbean Climate Hub (https://caribbeanclimatehub.org/projects/caribbean-drought-learning-network/) and held virtually on 8–9 September 2022. This meeting was unique as it combined progress updates and discussion sessions with a training

opportunity from within the network membership (i.e., workshop by SECARIBE research group on day 2). Meeting discussions centered around three main objectives:

1) Increase awareness of the scope of drought-related initiatives in PR and the USVI (day 1).
2) Promote peer-to-peer learning about the latest in drought research and communication (day 2).
3) Provide space for interaction across entity, organization, and island boundaries to enhance communication, knowledge sharing, and collaboration (days 1 and 2).

Meeting organization and participation

The first CDLN annual meeting aimed to provide a space to share drought updates, resources, and recent research pertaining to droughts in the Caribbean. The meeting brought together about 60 network partners from within the Caribbean region (i.e., PR, USVI, and Barbados) and mainland United States (i.e., Colorado, Nebraska, Virginia, Washington, and Louisiana). Participants included climate service providers, drought researchers, climatologists, extensionists, and other specialists from nongovernmental and governmental agencies such as the USDA CCH, the National Drought Mitigation Center (NDMC), the National Integrated Drought Information System (NIDIS), the National Weather Service (NWS), the Caribbean Regional Climate Centre at the Caribbean Institute for Meteorology and Hydrology, U.S. Forest Service International Institute of Tropical Forestry, U.S. Fish and Wildlife Service—Caribbean Ecological Services Field Office, Southeast Climate Adaptation Science Center, Farm Service Agency, Natural Resources Conservation Service Caribbean Area (NRCS), Puerto Rico Climate Office, Puerto Rico Department of Natural Resources, Puerto Rico Department of Agriculture, and the U.S. Virgin Islands Department of Agriculture. Academics and members of drought research groups such as the Caribbean Green Technology Center, University of the Virgin Islands, and SECARIBE also participated. SECARIBE, whose name is derived from the Spanish words for "dry" ("seca") and "Caribbean" ("Caribe"), is a collaborative initiative dedicated to the study of Caribbean droughts, particularly investigating how Saharan dust-rich air currents can lead to more frequent droughts in the region (Mercado-Díaz 2022).

Meeting overview

Drought-related initiatives in PR and USVI: Challenges and needs. The day started with key remarks from agency leaders including Dr. William A. Gould (National Lead for the USDA Climate Hubs), Positive T. Nelson (USVI Commissioner of Agriculture), and Ramón "Pirul" González Beiro (Puerto Rico Secretary of Agriculture), and a brief overview of the Caribbean Drought Learning Network by CCH Coordinator, Eva Holupchinski. Besides introducing participants to the main goals of the network, this overview clarified that the network leadership is based on adaptable collaboration between multiple agencies and is open to participation from anyone wishing to lead or contribute to initiatives. Details about the role of network leadership, teams, and network members were also defined.

The presentation "2022 Drought in Review" by NWS meteorologist Emanuel Rodríguez González was a notable contribution as participants learned key aspects about drought conditions in Puerto Rico since 2020. The NWS shared that Puerto Rico has been continually under "Moderate Drought" for some portion of its territory for the entirety of 2022 (Fig. 1). Drought conditions also worsened during some periods, most notably by June 2022, while same-month comparisons for August between years 2021 and 2022 (Fig. 2) confirmed that the year 2022 brought more severe drought conditions for Puerto Rico. These conditions

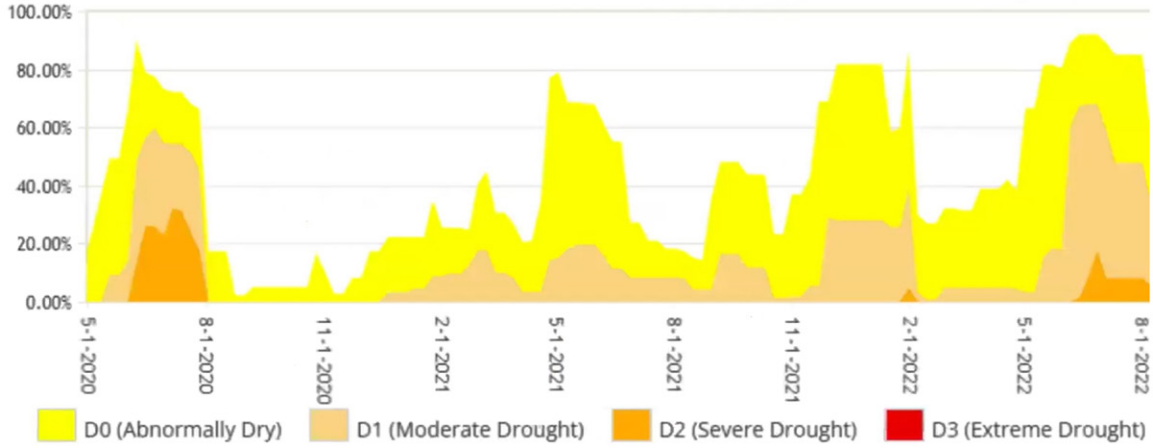

Fig. 1. Puerto Rico percent area in U.S. Drought Monitor categories between 1 May 2020 and 1 Aug 2022 (https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?PR).

intensified during a period of below-normal precipitation, particularly after May, which was also detected in St. Croix and resulted in a similarly anomalous dry period during these months. Yet, comparisons between year 2015 and 2022 in terms of percent area of Puerto Rico under U.S. Drought Monitor categories clearly demonstrated that drought conditions were more severe during the 2015 drought.

An important component of day 1 was the discussion on drought experiences from the past year. This portion invited participants to reflect on successes and lessons learned relating to their drought-related work. Participants were also invited to share needs to address as well as gaps in the participation of underserved societal sectors and their access to relevant drought information.

In the context of the multifaceted effects of droughts in water reservoirs of the region, participants highlighted the urgent need to either reinstall, refurbish, or replace key weather stations and hydrological sensors, particularly in the USVI. Soil Climate Analysis Network (SCAN) sensors from the USDA/NRCS and USGS gauging and well stations were identified as a priority. Concern for increased salinization of aquifers was mentioned as an important reason to improve monitoring. Major impediments for drought work in Puerto Rico and the USVI were identified: 1) relevant drought information is scattered across multiple platforms and can be difficult to navigate and monitor and 2) there is a lack of interconnectivity between monitors, stations, and sensors at both local and regional levels. To help address these impediments, the PR Climate Office at the University of Puerto Rico–Mayagüez Campus shared that they are integrating multiple sources of information into a single platform.

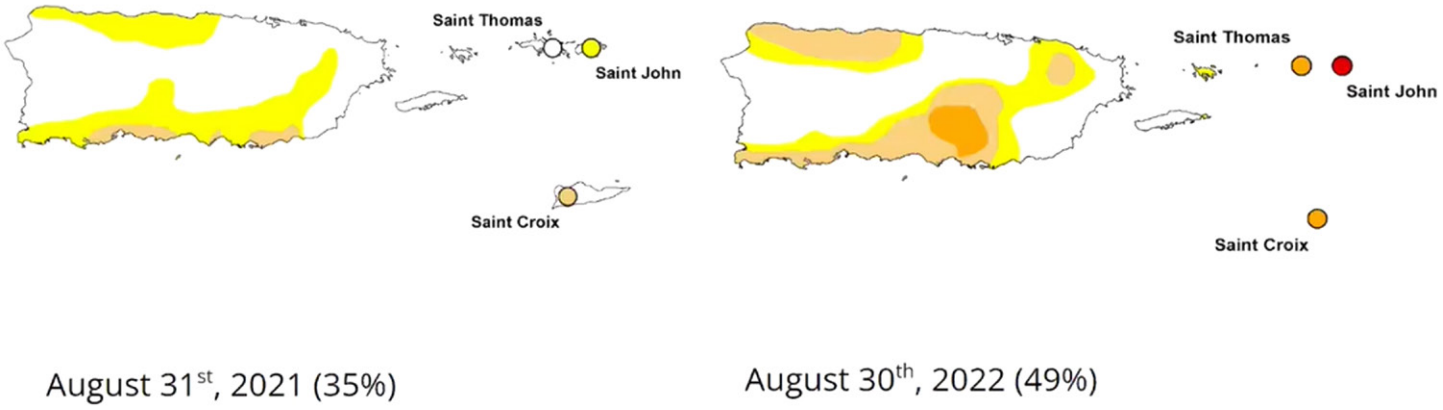

Fig. 2. Maps showing same month (August) comparisons between years 2021 and 2022 for areas in Puerto Rico and the U.S. Virgin Islands under different U.S. Drought Monitor drought classification categories.

Environmental changes in coastal ecosystems in this region appear to be occurring more frequently, such as *Sargassum* algal blooms. These observed changes are leading the public to reach out to drought experts to inquire about potential connection between droughts and these ecosystemic processes. As such, it was suggested that CDLN efforts and dialogs be directed at exploring the complexity of potential interactions between rainfall deficits and these types of environmental phenomena. Coupled with further development of models that more accurately calculate drought climatologies (e.g., https://droughtatlas.unl.edu/Data/Climate.aspx), such efforts could lead to more efficient planning and the development of resilient inland and coastal infrastructure. Furthermore, participants highlighted how critically connected the protection of soil cover is to drought management and mitigation. Developing and sharing available techniques to implement effective soil health practices was identified as a pivotal endeavor in this respect.

In recognition of their contribution to drought information systems in the Caribbean, a call for broader integration of regional partners in jurisdictions outside Puerto Rico and the USVI was raised. Participants noted that several institutions and climate centers such as the Caribbean Institute for Meteorology and Hydrology (CIMH) are somewhat peripheral to the CDLN due to the network's initial focus on Puerto Rico and the U.S. Virgin Islands. Because these entities provide vital drought data (e.g., forecasts, Standardized Precipitation Index products) that are critical for better understanding regional trends and informing decision-making processes, the CDLN leadership unequivocally recognized the added capacity of these organizations and stressed the need to strengthen connections between these partners and the PR/USVI-focused work of the CDLN.

Day 1 ended with a review of the early accomplishments of the CDLN. Dr. Nora Álvarez-Berríos, Co-Lead of the "Drought Impact Reporting and Citizen Science" team, reported on progress achieved in promoting the Condition Monitoring Observer Reports (CMOR) tool, which allows citizens to participate in drought impact reporting activities. She also highlighted increased interest in the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) volunteering program, which allows community members to directly participate in measuring and mapping of precipitation as citizen scientists. Conversely, Dr. Meredith Muth, team Co-Lead of "Drought Communication and Outreach," reminded participants to subscribe to the bimonthly PR/USVI Drought Status updates and announced an upcoming webinar series for network members.

Peer-to-peer learning: Flash drought dynamics and early warning systems in the Caribbean. Considering that the onset, development, and contributing factors of Caribbean drought vary markedly from the mainland, it is an urgent priority to develop tailored drought information for this region. Members of the SECARIBE research group, a collective of Caribbean drought researchers from both the mainland United States and PR, recognized these shortcomings and have been generating and sharing key drought information to fill these knowledge gaps. As part of these efforts, SECARIBE offered a workshop during the second day of this meeting. The drought experts of SECARIBE introduced workshop participants to currently available drought early warning and monitoring tools and shared new research on the recent flash drought dynamics for the region.

The first portion of this workshop was led by Dr. Paul Miller, who emphasized that a key aspect to properly dissect Caribbean drought dynamics is understanding the role of Saharan dust as a trigger for U.S. Caribbean drought events. Anomalous early pulses of Saharan dust were, for instance, an aggravating factor for the extreme drought in 2015. SECARIBE provided an orientation of drought monitoring tools to characterize physical properties of Saharan dust using satellite- and model-based products such as the Aerosol Index (https://rapidrefresh.noaa.gov/RAPchem/), which allows users to quantify how much sunlight is being absorbed

and scattered by the dust. The Integrated Dust Transport metric is a new tool that is currently being developed which focuses on the transport of Saharan dust.

For dust and drought forecasting needs, the Galvez–Davison Index (GDI; Galvez and Davison 2016) is a promising product based on the thermodynamic signature of the hot air layer associated with the Saharan dust (www.wpc.ncep.noaa.gov/international/gdi). As indicated by Dr. Miller, this tool was originally designed for near-term precipitation forecasting in the tropics, but work by SECARIBE has shown that the GDI also corresponds to precipitation on seasonal scales. However, more nuanced metrics will be required to anticipate future flash droughts. This is because flash droughts tend to develop in time scales that are comparatively shorter than events captured by the seasonal-scale GDI product that is currently in development.

Dr. Miller concluded with an interactive polling exercise in which participants were asked to provide feedback on personally or professionally valuable indicators of drought and those drought-related characteristics that they find most relevant to their needs. This participatory activity revealed that among participants, *low rainfall for an extended period of time* was the preferred drought indicator, whereas *degree of severity* was considered the most important drought characteristic (Fig. 3).

A reflection on personal connections with drought launched the second half of the workshop, led by Dr. Craig Ramseyer, who then focused on tropical flash drought dynamics and metrics. Flash droughts, or rapid-onset droughts, present challenges in the Caribbean, including impacts on water availability, agriculture, and forest health. As such, SECARIBE has been focused on tailoring metrics for application in this region, such as the Evaporative Demand Drought Index (EDDI), which have shown potential to improve our ability to forecast these types of events (Hobbins et al. 2016). The EDDI combines temperature, moisture, radiation, and wind variables to quantify how "thirsty" the atmosphere is at a specific point in time.

Overall, EDDI climatologies for the Caribbean region and Puerto Rico were reconstructed using machine learning and reanalysis data from the last 40 years. Preliminary analyses from the SECARIBE team show increasing trends in EDDI values for this region. Some of these climatologies correlate well with severe historical Caribbean droughts (e.g., 1994 and 2015), suggesting that high evaporative demand may have influenced these events. For Puerto Rico, EDDI provides improved short-term flash drought signaling when compared to traditional

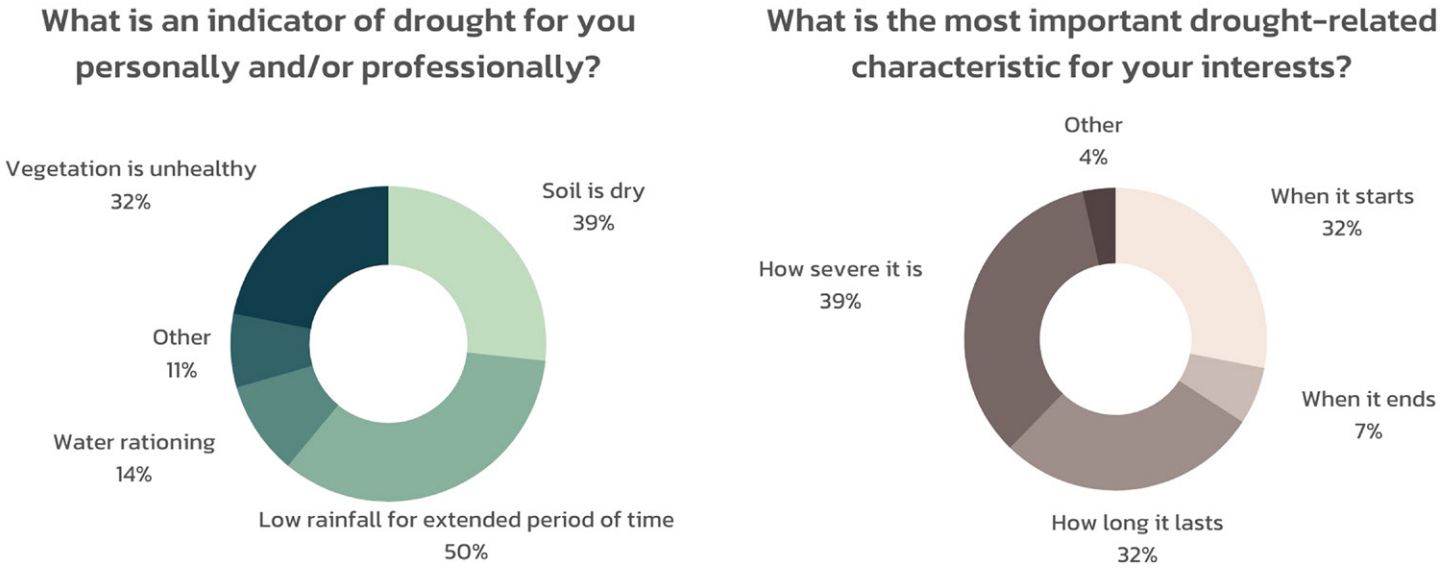

Fig. 3. Results from interactive polling during SECARIBE workshop. Questions were multiple choice, allowing for more than one selection and a total exceeding 100%.

drought metrics (e.g., soil moisture anomalies), thereby demonstrating its potential utility for flash drought early warning.

A proper working definition of flash droughts is also important for monitoring, modeling, and prediction tasks, particularly in the tropics where the phenomenon has been less investigated. In this vein, Dr. Ramseyer reiterated SECARIBE's adherence to Pendergrass et al.'s (2020) flash drought definition: "a 50th percentile increase in EDDI (toward drying) over 15 days, sustained for at least another 15 days." This is a rather strict definition that tracks the change of evaporative demand over short time frames. Meeting participants were subsequently introduced to patterns of flash droughts for the Caribbean and Puerto Rico that have met this criterion, such as the long-term Puerto Rican drought in 2015. Further, modeling efforts from SECARIBE show that some areas within the Caribbean region tend to be under flash drought regimes simultaneously. Some of these suggest, for instance, that when eastern Cuba, Jamaica, and Hispaniola are experiencing flash droughts, there is a high likelihood for Puerto Rico to be under a flash drought regime as well.

Closing remarks and next steps

Many sectors of society are engaged in planning for drought to mitigate negative effects, providing information and programs to help respond to and recover from drought, maintaining water infrastructure to avoid loss of water resources, and research to better understand risks and predict drought occurrence. Efforts such as the CDLN are extremely useful within this context as they help develop boundary organizations that can foster cross-sector learning and serve as a repository of information between drought occurrences.

The first CDLN Annual Meeting provided a space for knowledge and feedback exchange among drought leaders, researchers, and resources managers. Closing remarks focused on conversations about future directions for the network. Concerning SECARIBE's workshop and further advancement of research goals, participants highlighted the need to:

1) Connect research to action: The importance of operationalizing GDI, EDDI metrics, and other SECARIBE products to translate research into effective decision support tools.
2) Disseminate innovative research: Get better familiarized and use established platforms (e.g., www.drought.gov) to disseminate key research relevant to Caribbean drought monitoring and forecasting. The "Drought Status Update for Puerto Rico and the U.S. Virgin Islands" and a proposed DLN-sponsored webinar series could play a pivotal role in this regard.
3) Fill data gaps: Identify data that comply with requirements needed for properly estimating and modeling drought metrics highlighted by SECARIBE that are still unavailable for the USVI.
4) Continue the conversation: Organize a separate follow-up gathering to discuss further application to SECARIBE's research and potential use of an available water/energy budget dataset to model EDDI and other relevant drought metrics for the USVI.

Additional discussions to better understand how experience/perceptions about droughts relate to decision-making and ways people report back on local drought are also a top priority. Properly addressing these matters is tightly connected with the network's Drought Impact Reporting and Citizen Science team goals, which underscores the need to continually support their citizen science initiatives. These ultimately aim to improve drought monitoring across Puerto Rico and the U.S. Virgin Islands.

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Data availability statement. There are no data associated with this meeting summary.

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