ISSUE BRIEF

Using Citizen-Based Observations to Plan for Climate Change

A Look at the United States and Europe

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It is well documented that climate change is already affecting regions across the globe. Even if the global community can successfully limit greenhouse gas emissions, the impacts of climate change will still last decades into the future. In addition to implementing mitigation efforts, many communities are already planning for climate change and adopting measures to adapt to projected scenarios and prepare for potential surprises. While national governments and international organizations have a major role to play in supporting climate adaptation efforts at all levels of governance, these efforts ultimately should be tailored to the local level, as the type and magnitude of climate change impacts vary greatly across regions.

To prepare for climate change at the local level, it is important to engage local citizens. Input from local citizens can help verify the impacts of this phenomenon on the ground and ensure that identified solutions fit the specific conditions and needs of that location. Furthermore, engaging local citizens in climate adaptation efforts increases the capacity of communities to adjust to future changes.

One way to engage local communities is through citizen-based observation networks. This strategy improves the adaptation process by allowing for the collection and sharing of crucial environmental data across communities and regions. These networks encourage members of the public to submit observations about their local environments, which can then typically be accessed using a public online platform. By making these observations public, researchers, decision-makers, and citizens are able to view and analyze information gathered across space and time. In the European Union (EU), the term "citizens' observatory" is often used to refer to such information networks.

Citizen-based observation is a form of "citizen science," a more readily understood term that has grown in popularity in recent years. According to the US National Oceanic and Atmospheric Administration, citizen science is "a form of open collaboration where members of the

The **Emerging Leaders in Energy and Environmental Policy** (ELEEP) Network is a joint project of the Atlantic Council's Millennium Leadership Program and the Ecologic Institute, an independent nonprofit think tank and applied research organization focused on environmental policy. The Millennium Leadership Program provides exceptional leaders aged thirty-five and under with unique opportunities to build a global network, engage directly with world leaders at flagship Atlantic Council events, develop key professional skills, and collaborate to have a global impact.

public participate in the scientific process to address real-world problems in ways that include identifying research questions, collecting and analyzing data, interpreting results, making new discoveries, developing technologies and applications, and solving complex problems."[1] With advances in technology, crowdsourcing has become a popular way to share and pool information for diverse applications—from spreading new ideas to navigating traffic—in real time.

Citizen-based observation networks build on the concepts of citizen science and crowdsourcing. With respect to climate change, citizen-based observation networks have great potential to help scientists, decision-makers, and the public understand its varied impacts across regions. These networks also have the potential to increase information-sharing across local and international boundaries to support continued learning in light of new, and sometimes unexpected, challenges.

This paper explores the potential of citizen-based observation networks when used as a tool for sharing information in ways that can help local communities prepare for the impacts of climate change. The first section presents several examples of these networks in the United States and Europe and the second uses these examples to explore the networks' potential benefits and challenges. The third part describes recent policies and initiatives that support the increase of these networks in the United States and Europe. The issue brief ends with three overarching recommendations to expand the use of community-based observation networks in local, regional, national, and international climate adaptation efforts.

Citizen-Based Observation Networks: Examples from the United States and Europe

There are numerous examples of citizen-based observation networks throughout the United States and across Europe. These networks help local communities and decision-makers in all levels of government prepare for the ramifications of a changing climate.

1 "Citizen Science and Crowdsourcing," National Oceanic and Atmospheric Administration, http://www.noaa.gov/office-education/citizen-science-crowdsourcing.

USA National Phenology Network

The USA National Phenology Network (USA-NPN)[2]—whose activities are supported by several federal government agencies and academic partners[3]—promotes enhanced understanding of plant and animal phenology[4] and highlights changes to these phenologies over short and long timescales. To achieve its goals, the USA-NPN maintains Nature's Notebook, a network that allows members of the public to submit observations online or through a mobile application. Users can track events, such as the autumnal arrival of migratory birds at a specific site, or the appearance of sunflowers as they emerge from the soil, produce leaves, and flower.[5] USA-NPN also offers a tool to visualize and analyze data across seasons, regions, and species. The network tries to standardize its monitoring approach and improve the quality of data that it collects by offering detailed protocols and training materials to its citizen scientists.

Phenology is a key indicator of climate change impacts. Changes in phenological life cycles of plants and animals are already observed anecdotally by people around the world. Therefore, formalizing these observations through established networks will allow for a more systematic method of tracking, comparing, and analyzing these changes. To this end, the US Global Change Research Program has proposed a prototype set of national climate change indicators,[6] including the "start of spring" indicator, which is calculated and validated using data from USA-NPN and Nature's Notebook. The results have the potential to support many decision-makers and resource managers who must account for changing environmental variables such as fire seasons and flora and fauna ranges.[7]

2 USA National Phenology Network, https://www.usanpn.org.

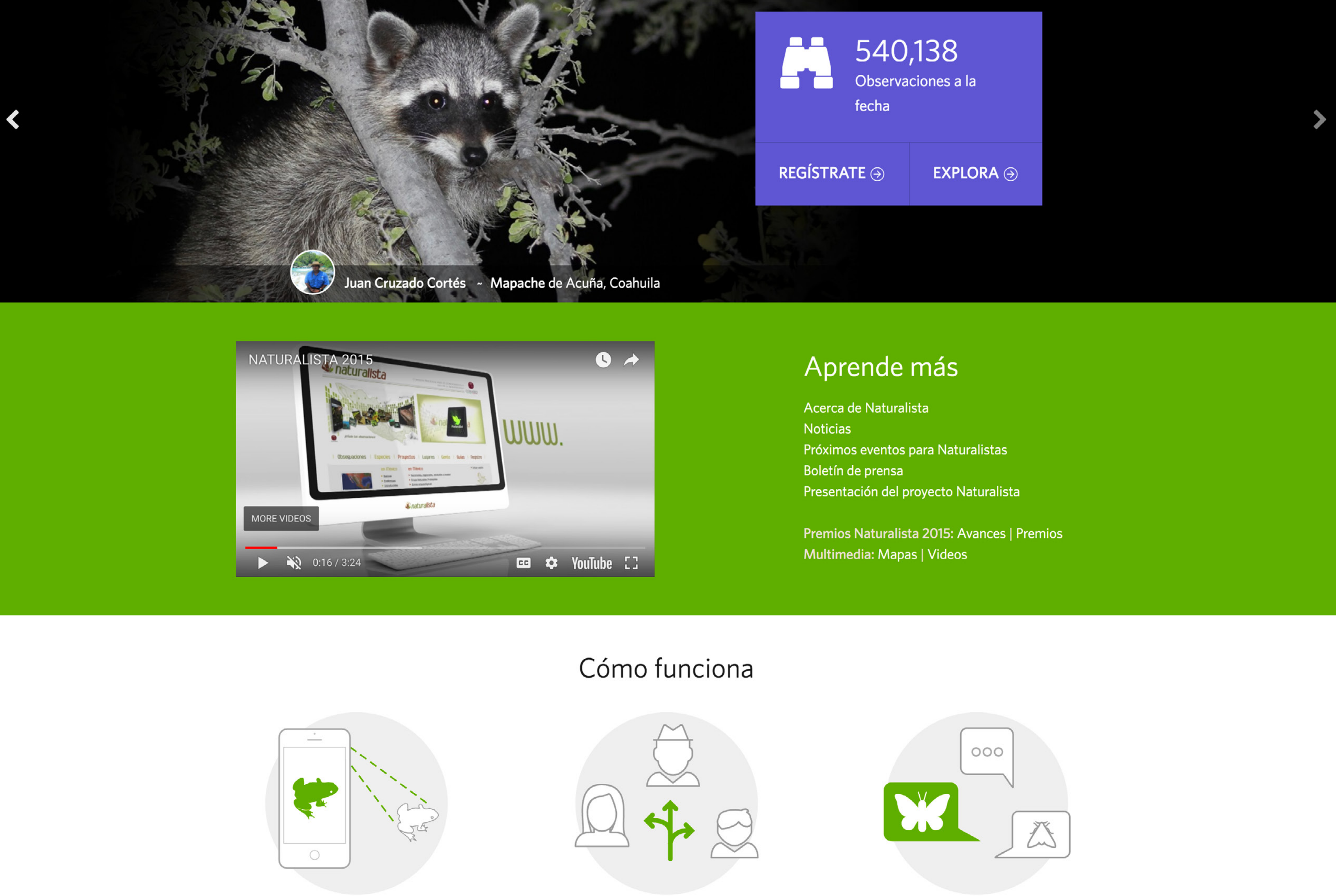
3 "About Us," USA National Phenology Network, https://www.usanpn.org/about.

4 According to the USA National Phenology Network, phenology refers to recurring plant and animal life cycle stages. It is also the study of these recurring life cycle stages, especially their timing and relationships with weather and climate.

5 US Geological Survey (USGS) and the USA National Phenology Network, "The USA National Phenology Network - Taking the Pulse of Our Planet," 2011, https://www.usanpn.org/files/shared/files/USA-NPN_factsheet_March2011.pdf.

6 "Indicators," U.S. Global Change Research Program, http://www.globalchange.gov/explore/indicators.

7 "Phenology: A National Indicator," USA National Phenology Network, https://www.usanpn.org/about/national-indicator.



La Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), based in Mexico, is an organizational node of the iNaturalist Network. CONABIO operates the NaturaLista website, which connects to the iNaturalist software. *Photo credit*: www.naturalista.mx/.

iNaturalist

iNaturalist is a global network that allows citizen scientists to submit observations of biodiversity, either online or through a mobile app. iNaturalist also allows experts to crowdsource identifications of observed organisms. The quality of an observation is "graded" based on its levels of verification. A submitted observation is classified as "research-grade" when it includes coordinates, a photo, and a date, and when the community agrees on the identification of the species that has been observed.[8] iNaturalist also allows users to create "projects," or iNaturalist sub-communities, in order to track more specific types of information. Several existing projects, for example, are aimed at improving global understanding of coral reefs, and how they might be impacted by climate change.

Developed at the University of California, Berkeley, in 2008, iNaturalist was acquired by the California Academy of Sciences in 2014.[9] The network shares its data with a number of other platforms. For example, Biodiversity Information Serving Our Nation (BISON)[10] builds on research-grade iNaturalist data and a range of other sources (e.g., monitoring programs, peer-reviewed literature) to share millions of plant and animal species' observation records publicly.[11] BISON, maintained by the US Geological Survey, is a useful tool for visualizing species' occurrences and distribution. Moreover, it can be used to analyze how species' ranges and population sizes are shifting with a changing climate. Users can search for species within a specific geographical area (e.g., state, county, customized location) to see how occurrence is changing over time. The range of data offered by BISON is enhanced by the addition of iNaturalist citizen science data.

8 "Help," iNaturalist, http://www.inaturalist.org/pages/help.

9 "About Us," iNaturalist, https://www.inaturalist.org/pages/about.

10 "Home," USGS, Biodiversity Information Serving Our Nation (BISON), https://bison.usgs.gov.

11 "Data Providers," USGS, BISON, https://bison.usgs.gov/#providers.

iNaturalist is a global community that enables information-sharing across national boundaries, and consists of organizational "nodes" that operate in the United States, Canada, Mexico, New Zealand, and Colombia.[12] Collectively, these organizational nodes are known as the iNaturalist Network, and they manage nationally tailored websites (e.g., inaturalist.ca or naturalista.conabio.gob.mx) that connect to the iNaturalist software. The iNaturalist Network allows organizations to more effectively engage the public by tailoring the software's features and interface to their respective national contexts.

WeSenseIt Citizen Water Observatories

In 2012, as part of the European Union's Seventh Framework Programme for Research and Technological Development (2007-2013), five citizens' observatory projects received funding under the topic "developing community-based environmental systems using innovative and novel earth observations applications."[13] One of these projects, WeSenseIt Citizen Water Observatories, began in October 2012 and developed crowdsourcing applications in different pilot regions. One of the project's pilot areas was the densely populated Delfland region of the Netherlands, home to 1.4 million people. The applications allow citizens to submit observations about various aspects of the water environment (e.g., flooding occurrence, water quality, and the built infrastructure) in their respective locations.[14]

Today, the applications from WeSenseIt help decision-makers access and visualize a range of information. For example, the WaterDetective application allows observers to submit photos of a clogged drain or a ditch that has overflowed. These types of observations can serve as quick references for water managers preparing for extreme weather events. As such events rise in frequency and intensity, and as climate change increasingly impacts water quality, tools like those produced by the WeSenseIt initiative can prove valuable for ensuring the resilience of water environments and the communities around them.

12 "What Is It," iNaturalist, https://www.inaturalist.org/pages/what+is+it.

13 European Commission, *FP7 Work Programme 2012: Environment*; European Biodiversity Observation Network, "Citizens' Observatories: Five EU FP7 Projects Focused on Citizen Science," September 23, 2014, http://www.eubon.eu/news/11594_citizens%E2%80%99-observatories-five-eu-fp7-projects-focused-on-citizen-science-/.

14 WeSenseIt, http://www.wesenseit.com/.

GROW Observatory

Other citizens' observatories are emerging or in the early stages of development throughout Europe. The EU's Horizon 2020 research and innovation program (2014-2018) provided funding to four more citizens' observatory projects in 2016.[15] One of these initiatives, the GROW Observatory,[16] aims to share land, water, and soil resource information across Europe. By encouraging the collection of local soil moisture observations, the GROW project hopes to validate the soil moisture data provided remotely by satellites. Soil moisture is an important indicator of extreme climate events, such as flooding, drought, and heat waves.[17]

GROW also explores ways to support participants with monitoring protocols, soil testing kits, and low-cost sensing technology. As the GROW network expands, the aim is to establish an active online community of growers and land managers that share not only data, but knowledge and advice on best practices for managing soil and growing food. In addition to providing important data for dealing with extreme events, GROW will also establish a network of people equipped to preserve the quality of land and soil resources in the face of climate change.[18] Soil quality is an important factor in carbon sequestration and ensuring the production of high-quality food—challenges that will grow with climate change.[19]

LEO Network

The Local Environmental Observer (LEO) Network[20] is a community-based observation network with origins in Alaska that is poised to expand across the United States, Mexico, and the circumpolar Arctic.[21] In Alaska

15 "About," Citizens' Observatories, http://citizen-obs.eu/about/.

16 GROW Observatory, http://growobservatory.org/.

17 Kirien Whan, Jakob Zscheischler, Rene Orth, Mxolisi Shongwe et al., "Impact of Soil Moisture on Extreme Maximum Temperatures in Europe," *Weather and Climate Extremes* 9, 2015: 57-67.

18 University of Dundee Centre for Environmental Change and Human Resilience, *The GROW Observatory – An EU-Wide "Citizen Science" Project*, September 5, 2016, https://www.dundee.ac.uk/cechr/news/2016/articles/the-grow-observatory--an-eu-wide-citizen-science-project.php.

19 R. Victoria et al., "The Benefits of Soil Carbon," in *UNEP Year Book 2012*, United Nations Environment Programme, Nairobi, http://staging.unep.org/yearbook/2012/pdfs/UYB_2012_CH_2.pdf.

20 Local Environmental Observer Network, https://www.leonetwork.org/en/.

21 "Local Environmental Observer Network (LEO)," Commission for Environmental Cooperation, http://www.cec.org/our-work/projects/local-environmental-observer-network-leo; Arctic Contaminants Action Program, "Circumpolar Local Environmental

and the Arctic, temperatures are rising at twice the global average rate.[22] As a result, communities in the region are already experiencing deep impacts to their environment and way of life.

The LEO Network engages communities on the front lines of climate change by collecting information on anomalous environmental events. For example, observers can report when sea ice melts earlier than seasonally normal or when mass numbers of a particular species die at once, the latter of which can be an early indicator of disease related to a changing climate. These observations are important contributions in a region where data availability is often quite poor. Many of the communities that contribute to the LEO Network have a deep connection to the land. Thus, continuous monitoring of the surrounding environment is crucial to ensuring the health of these communities.

LEO members can submit observations, with added commentary, using a mobile application. Attaching notes allows participants to put their observations into context, which is particularly important for observers from indigenous communities. These groups can add indigenous and/or local knowledge,[23] particularly with respect to their communities' own experiences and historical observations. The LEO Network also engages scientists and other experts, who advise community members on observations of concern.

The LEO Network, maintained by the Alaska Native Tribal Health Consortium and supported in part by the US Environmental Protection Agency, has also been actively identifying partner organizations in order to expand. Due to the program's success in Alaska, the White House announced in September 2016 that the program will expand both to the lower forty-eight US states, as well as across international borders.[24] The Commission for Environmental Cooperation, a trinational organization consisting of the United States, Canada, and Mexico, has announced its support for expanding the LEO Network across North America.[25]

Under the Arctic Council, partners are working to establish a foundation for a Circumpolar Local Environmental Observer Network (CLEO).[26] A CLEO would cover both the North American and European Arctic and provide a mechanism for communities to share observations about their changing environments across international borders. Sharing information and experiences is an important pillar of a region-wide Arctic approach to adaptation and resilience. Given that communities in the same region often face similar challenges, a CLEO could help establish stronger networks and share information across the Arctic.

Benefits and Challenges

Supporting citizen-based observation efforts could have many benefits for climate change adaptation and resilience. In remote areas, such as the Arctic, the public availability of physical and biological data can be sparse, while the costs and time associated with collecting these data can be significant. However, planning for climate change and undertaking adaptation measures are difficult without proper baseline observations and consideration of additional trends. Citizen-based observation efforts can increase the availability of data in remote areas. Along with indigenous and/or local knowledge of historical events and trends, projects such as the LEO Network can provide an opportunity for community members to integrate individual observations into the broader context.

Citizen-based observation networks also increase local engagement and preparedness. Participants in the networks become invested in the information they collect and are therefore more likely to understand environmental trends and plan for the future. Because effective adaptation requires locally tailored solutions, it is important to support the capacity of local citizens to understand and address the changes they observe.

Additionally, citizen-based observation networks connect people. iNaturalist brings citizen observers and experts together to discuss observations and crowdsource species identifications. The GROW

Observer Network," February 23, 2016, https://www.arctic-council.org/images/PDF_attachments/CLEO_meeting_docs/2016-02-23-v3-ACAP-CLEO-one-pager.pdf.

22 J. Overland et al., "Surface Air Temperature" in *Arctic Report Card 2016*, Arctic Program, http://www.arctic.noaa.gov/Report-Card.

23 According to the United Nations Educational, Scientific, and Cultural Organization, indigenous and local knowledge refers to the understandings, skills, and philosophies developed by societies with long histories of interaction with their natural surroundings.

24 The White House (archived), "Fact Sheet: The 8th Annual White House Tribal Nations Conference," September 26, 2016, https://obamawhitehouse.archives.gov/the-press-office/2016/09/26/fact-sheet-8th-annual-white-house-tribal-nations-conference.

25 "Local Environmental Observer Network (LEO)," Commission for Environmental Cooperation.

26 Arctic Contaminants Action Program, "Circumpolar Local Environmental Observer Network."

initiative will eventually result in an EU-wide network that will share information and best practices for the conservation of soil quality. The LEO Network has the potential to connect observers across all of North America and the circumpolar Arctic. Sharing information and connecting citizens can spur learning between regions and lead to innovation.

Finally, citizen-based observation initiatives allow communities to monitor the effectiveness of adaptation programs and adjust accordingly. When developing adaptation plans, communities can consider how citizen-based observation networks can be used as part of a monitoring and evaluation plan.

Of course, citizen-based observation networks can also face a few challenges. While they can be especially beneficial in remote areas, internet connectivity in these places can be limited, making it difficult to submit data points in real time. Additionally, as these networks expand, approaches become more decentralized, which could lead to observer bias or variations in data quality. To alleviate these issues, many networks have implemented standardized guidelines and provide training opportunities for observers, both online and in person. The training encourages a higher level of data quality and enhances decision-makers' ability to compare data across observation points. Furthermore, organizations such as the Citizen Science Association are emerging to provide monitoring guidelines and best practice recommendations across citizen-based observation initiatives. Despite the challenges associated with these networks, recent policies suggest a growing acknowledgment that the advantages outweigh the potential risks.

Top-Down Support for Participatory Monitoring

While citizen-based observation networks are often developed from the bottom up, national and multilateral organizations have taken note of their potential. The US federal government has long supported the development of several citizen-based observation networks. The benefits of citizen science and crowdsourcing were more formally recognized by law in January 2017 through the American Innovation and Competitiveness Act,[27] which granted federal agencies the explicit authority to use crowdsourcing and citizen science. The law acknowledged that these methods help advance the federal government's responsibilities, and recognized the ability of citizen science and crowdsourcing to increase effective spending, address societal issues, and engage members of the public. In addition, the law formalized the position of a US chief technology officer (CTO). It is too soon to tell if and how the Donald Trump administration plans to advance crowdsourcing and citizen science efforts, but further top-down policies may be influenced by the appointment of a CTO. A CTO had not been nominated at the time of publication.

Countries across Europe are adopting programs or outlining citizen science approaches at the national level.[28] While the EU has not formalized citizen science policies,[29] the European Commission has shown support for the concept through initiatives such as FP7 (2007-2013) and Horizon 2020, the European Commission's research and innovation program. The current 2016-2017 Work Programme (climate action, environment, resource efficiency, and raw materials) for Horizon 2020 identifies the coordination of community-based environmental monitoring initiatives—again referred to as citizens' observatories—and promotion of best practices as priorities.[30] It envisions a coordinated network of environmental monitoring initiatives that can be integrated with traditional Earth observation systems and contribute to more informed decision-making actions by local environmental and emergency managers. As shown by the expansion of the LEO Network, many multilateral organizations such as the Arctic Council and the Commission for Environmental Cooperation support citizen-based observation networks.

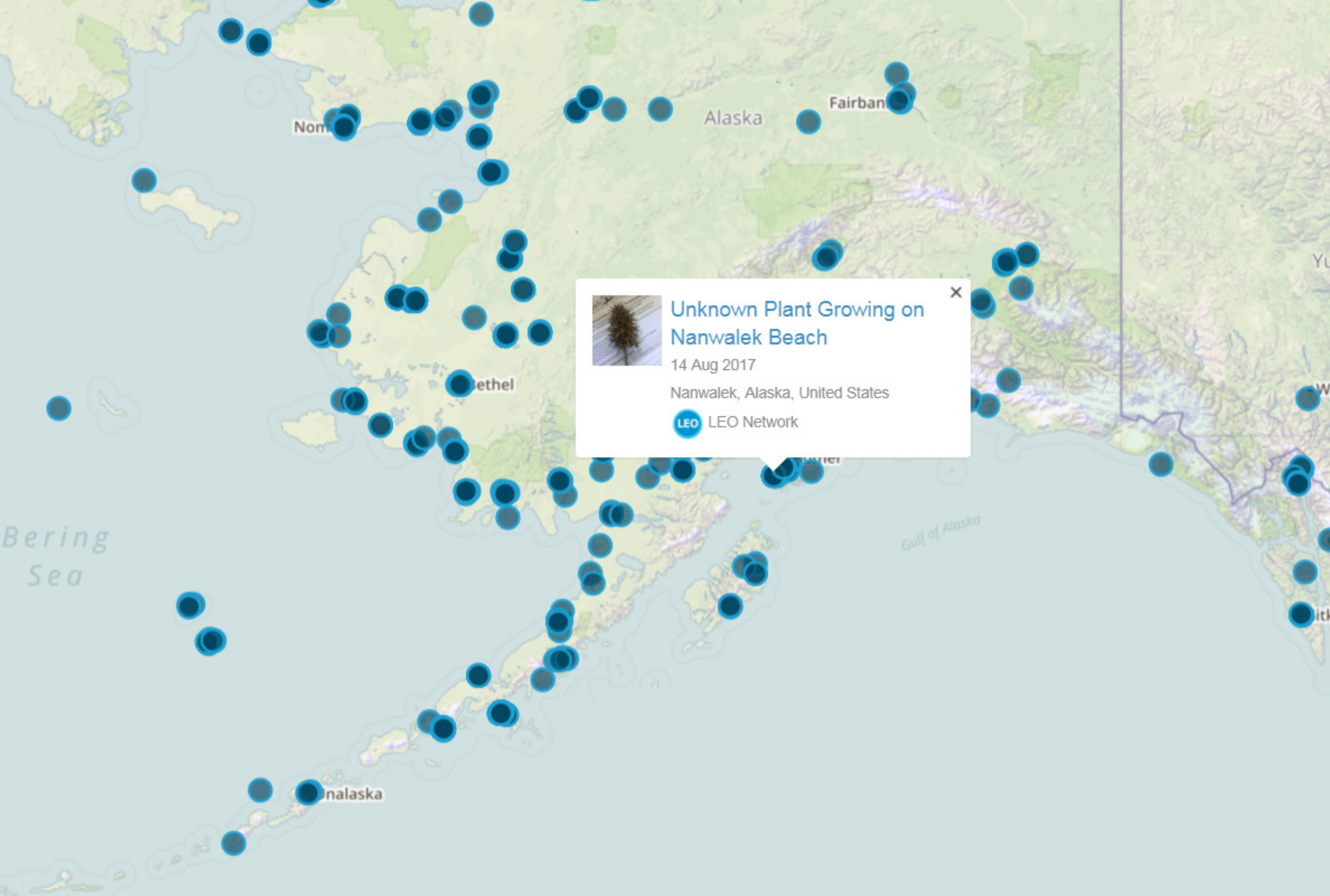
Outside of government, nonprofit organizations also support the coordination of citizen-based observations and citizen science efforts. The Citizen Science

27 "S.3084—American Innovation and Competitiveness Act of 2017," Congress.gov, United States Government, 114th Congress, https://www.congress.gov/bill/114th-congress/senate-bill/3084.

28 A. Bonn et al., *Citizen Science Strategy 2020 for Germany*, Bürger Schaffen Wissen, 2016, http://www.buergerschaffenwissen.de/sites/default/files/assets/dokumente/gewiss_cs_strategy_englisch.pdf.

29 Muki Haklay, *Citizen Science and Policy: A European Perspective, Woodrow Wilson International Center for Scholars*, 2015, https://www.wilsoncenter.org/sites/default/files/Citizen_Science_Policy_European_Perspective_Haklay.pdf.

30 European Commission, *Horizon 2020, Work Programme 2016-2017*, Climate Action, Environment, Resource Efficiency and Raw Materials, April 24, 2017, https://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-climate_en.pdf.



The Local Environmental Observer (LEO) Network website includes an interactive mapping tool to view observations by location. *Photo credit*: www.leonetwork.org.

Association[31] is a nonprofit organization that coordinates citizen science activities, connects practitioners, and offers guidelines and best practices. Furthermore, the European Citizen Science Association,[32] established in 2013, coordinates citizen science activities across the EU in hopes of encouraging and increasing citizen science efforts, while connecting actors across Europe that are involved in planning and promoting citizen science programs.

Recommendations

Citizen-based observation networks are growing in the United States and Europe and present opportunities for the development of relevant programs. Governments at all levels, international organizations, networking organizations, and even citizen-based observation networks themselves all have a role to play in supporting the expansion of these networks.

The following overarching recommendations should be considered to expand the use of citizen-based observation networks to better plan for and address climate change impacts.

1. **Policy makers, planners, and decision-makers should consider using citizen-based observation networks as an integral part of local, regional, and national climate adaptation strategies.** The benefits of participatory monitoring and its contribution to the climate adaptation and resilience-building process of local communities are increasingly recognized. To maximize the benefits of these methods, policy makers and planners should consider integrating citizen-based observation efforts into their adaptation and resilience strategies. Doing so would prioritize support for citizen-based observation networks and ensure their connection to other adaptation and resilience activities.

31 Citizen Science Association, http://citizenscience.org/.

32 European Citizen Science Association, https://ecsa.citizen-science.net/.

2. **Governments at all levels, along with multilateral organizations, should consider formalizing the use of citizen science and citizen-based observation networks through policies.** While the decentralized nature of citizen science may lead to some hesitation on its formal endorsement from policy makers, it is important to recognize the potential benefits and cost savings, especially in the face of increasing climate change impacts. Formal policies can further promote citizen science and citizen-based observations as useful and authoritative tools for solving problems. These policies should be considered at the international, regional, national, and sub-national levels.

3. **Where feasible, governments, peer-to-peer learning organizations, and observation networks themselves should work together to connect citizen observation networks.** As the use of participatory monitoring efforts grows, it is important that these efforts are coordinated to the maximum extent possible. Collaboration saves resources and raises awareness among users about the information available through various networks. There is also potential to share experiences and observations of local environmental changes across international borders. Communities, nations, and regions of the world will need to be flexible and adapt their climate adaptation approaches to the changing conditions and challenges. Using citizen observation networks is one way to ensure that people across the world can learn from each other and better prepare for and adapt to changes brought about by climate change.

Conclusion

The establishment and use of citizen observation networks is growing across the United States and Europe. These networks can and should be used as tools for understanding climate change impacts and building local communities' capacity for adaptation and resilience to environmental changes. As the benefits of citizen science are increasingly recognized at the national and international levels, there is great potential for linking citizen observation networks to facilitate knowledge-sharing across both local communities and international borders. There is no one-size-fits-all approach to prepare for climate change—rather, climate change adaptation undoubtedly requires a wide range of solutions. Citizen observation networks are critical tools for helping communities and countries become better prepared for climate change impacts now and in the future.

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