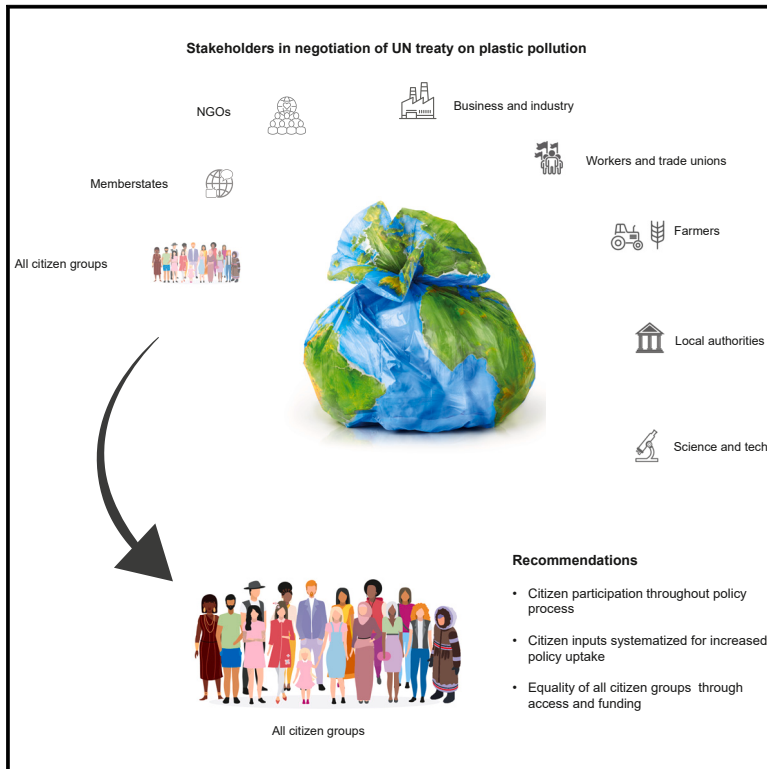# UN plastic treaty must mind the people: Citizen science can assist citizen involvement in plastic policymaking

Graphical abstract

Stakeholders in negotiation of UN treaty on plastic pollution

NGOs

Business and industry

Memberstates

Workers and trade unions

All citizen groups

Farmers

Local authorities

Science and tech.

Recommendations

- Citizen participation throughout policy process
- Citizen inputs systematized for increased policy uptake
- Equality of all citizen groups through access and funding

All citizen groups

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In brief

As member countries prepare for the INC2 negotiations of the UN plastic treaty, this study provides recommendations for how UNEA can include the public in the development and implementation process. We analyze citizen engagement initiatives currently employed in the EU to examine who gets a say and how it impacts policy. Furthermore, we discuss how citizen science methods, by collaborating with citizens effectively, can offer potential for scientific knowledge generation, increased policy participation, and policy influence.

Highlights

- Citizens are central stakeholders in development of the UN treaty on plastic pollution

- Current channels engaging EU citizens in plastic policymaking are a work in progress

- Citizen science can aid data generation, citizen collaboration, and policy influence

- We recommend ways the treaty can implement citizen science for an effective treaty

CellPress

Article

UN plastic treaty must mind the people: Citizen science can assist citizen involvement in plastic policymaking

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SCIENCE FOR SOCIETY Plastic pollution is omnipresent in the environment and has been for decades. An important step toward tackling plastic debris on a global scale from source to sea was taken as negotiations of the United Nations treaty to end all plastics pollution began in late 2022. Citizens are a central stakeholder in successfully creating societies and environments free from plastic pollution. In this paper we look to the European Union—which has many years of experience in engaging the public in policymaking—and to the citizen science methodology to see what can be learned for the creation of the UN treaty. Based on these insights, we recommend to the Intergovernmental Negotiation Committee and the UN Environment Assembly that, among other things, the public ought to be heard throughout the policy process, that systems for harmonization and sharing of policy input should be prioritized, and that equal access for all participants should be ensured in all development and implementation stages.

SUMMARY

By 2024, the United Nations treaty to end all plastic pollution is set to join multilateral forces to act on plastic pollution. While involving citizens has the potential to improve policy implementation, legitimacy, and relevance, effective measures are currently lacking in plastic pollution policy. Here, we aim to build on existing praxis in the European Union and analyze current initiatives engaging citizens. We discuss these in a citizen science context and provide recommendations for an effective treaty. We find that current measures are inadequate, that policy impact is contingent on the policy phases and the input type, and we highlight opportunities for citizen science to support public access to policy influence. We recommend that the upcoming treaty ensures access throughout the policy process, that inputs are systematized and harmonized to increase application and policy uptake, and finally, consistent equity in participation for citizens affected by plastic pollution.

INTRODUCTION

In 2020, the United Nations Environment Program (UNEP) declared a "triple planetary crisis" for the state of humankind's imprint on the planet with an emphasis on climate change, biodiversity loss, and pollution, including plastic pollution.[1] Thus, the world watched as efforts to develop the first legally binding instrument to combat plastic pollution were endorsed at the UN Environment Assembly (UNEA) in Nairobi, Kenya, in March 2022. By 2024, the United Nations (UN) treaty to end all plastic pollution is to represent a multilateral commitment to take global action on plastics from source to sea.[2] The first "open-ended working group to end plastic pollution" was held in May 2022, and from the opening speech by the executive director of the UNEP, Inger Andersen, it was evident that the UN will look to all stakeholders, including citizens, in developing and effectively implementing the agreement.[3] It is well established that involving citizens in environmental decision-making is necessary to improve implementation, legitimacy, and relevance—and thus institutions at all governance levels have much to gain if they

provide access for the public to have a say.[4–6] With the historic agreement underway, the UN now has a unique opportunity to involve all citizens including persons, groups, and peoples in vulnerable situations that until now have remained unrepresented in decision-making processes on plastic pollution, such as Indigenous peoples, workers, children/youth, and women,[7,8] in helping forge an ambitious global treaty to fight plastic pollution. Specifically, concerning the UN plastic treaty, the UNEA has called "for the widest and most effective participation possible,"[9] This is by the Center for International Environmental Law (CIEL), highlighted as pertinent for an effective and equitable treaty and emphasizes the necessity of building on lessons from previous efforts to engage the public in similar agreements.

The first of five Intergovernmental Negotiation Committee meetings (INC1) took place in Uruguay from November 28 to December 2, 2022, and initial steps were taken to scope the plastic treaty. These negotiations are under the purview of the established mechanism for including non-state actors in international negotiations known as the Major Groups and Other Stakeholders (MGS) system.[7] However, strong criticism was raised after the INC1 about how the stakeholder forum worked due to the belief that certain stakeholders, like industry, dominated the process and prevented other stakeholder groups from providing input, including those that represented citizens. Break Free From Plastic (a coalition of more than 2,700 organizations working on plastic pollution) stated that the industry lobby had too much influence and that the work in the multistakeholder forum was used to delay and bypass central negotiations.[10] This critique led to the termination of the stakeholder forum in the current construction for the recent INC2 in Paris and highlighted the need for better involvement of all stakeholders.[11]

Drawing from previous experience with participation efforts within the European Union (EU) may provide the UN with valuable inspiration for the development of the coming plastics treaty. The intergovernmental EU has an overarching aim to stay connected to European citizens and has decades of experience with direct citizen involvement in policymaking through a variety of regional and local citizen engagement (CE) initiatives.[12,13] For example, extensive efforts have been rolled out to ensure involvement and democratic rights for civil society with the Better Regulation package in 2015.[14] Among several toolkits for enhanced decision-making, the Better Regulation toolkit #4 presents detailed descriptions of "evidence-based better regulation" including the data types that are considered sound evidence for policymaking: qualified data, quantified data, and opinions.[15] Also, and more specifically regarding the environment, the EU missions in Horizon Europe 2021–2027 encourage and rely on the European people to assist in combating some of the most pressing challenges concerning human health and the environment.[16] The same goes for the European Commission's (EC) Green Deal from 2019, stating specifically how citizens play a crucial part in designing policies if they are to be impactful.[17]

Similar to the EU, the UN acknowledges that citizen participation in global governance is an important element in ensuring acceptance and effectiveness.[18,19] In a global context, the UN aims to protect the fundamental human rights of the citizens of the world, which includes assigning a right to the people to "take part in the conduct of public affairs, directly or through

freely chosen representatives."[20] Concerning the UN plastic treaty, barriers to participation in the treaty negotiations may include restricted digital access, economic limitations, time differences, and general organizational resources.[7] More recently, citizen science (CS)—the cocreation and cooperation with citizens in the generation of scientific information and knowledge—monitoring data has been used to shed light on the state of the environment for the SDGs as presented by Fritz et al.[21] The study cements the applicability of CS serving as relevant policy information and argues that these new data sources could improve the already existing monitoring data from national statistical offices and governmental institutes in terms of costs, spatial variation, and data openness.[21,22] Schade et al.,[23] too, argue for the legitimacy of citizen participation in the form of CS by referring to SDG 17, titled "Partnerships for the goals: Strengthen the means of implementation and revitalize the global partnership for sustainable development," where public participation in scientific research is directly encouraged.[23] Moreover, Fraisl et al. reviewed 244 indicators for the SDGs in terms of whether CS directly or indirectly contributes to the indicator framework.[24] They found that CS already is or has the potential to be applied in the case of 33% of the SDG indicators and thus proves to provide an obvious path toward consistent and quality SDG monitoring and reporting. Likewise, a very recent project in Ghana proves that CS data can be implemented for high-level official monitoring of national marine plastic debris.[25] The direct policy impact of CS data collections for emerging economies to contribute to and deliver on SDG monitoring is imperative to have established as it invites application in other countries.

In this study, we aim to identify CE initiatives introduced by the EU related to plastic pollution and analyze impacts on the policy process to provide specific recommendations for the upcoming shaping of the UN treaty. In this context, we study the citizen impact in several or all policy phases and whether the type of data input plays a central role. Moreover, central aspects, such as the inherent scientific approach, of CS suggest a fitting channel for citizen influence, as monitoring plastic pollution through CS methods provides quantitative data that are highly needed for policy. Together with lessons from the participation efforts of the EU, a sound basis for tangible recommendations includes data harmonization and openness, access throughout the policy process, equity for all citizen groupings, and alignment of processes between regional, national, and local actions and policy.

RESULTS

We conduct our study by first identifying current CE initiatives relevant to plastic pollution policy under the EU through a non-exhaustive search of relevant sources. This included scrutinizing the Joint Research Center's database of CE initiatives in the EU, the general EU website for citizen participation, and the Horizon Europe missions descriptions. We then map these initiatives in a five-stage policy process cycle, also used as an illustration in literature and by the EC, to analyze where citizens have access to influence.[26,27] Further, we analyze three of the ten CE initiatives that represent quantified, qualified, and opinion types of evidence outcomes, namely, the "Have your say" portal, the European Citizens' Initiative, and the Europeanization of the Plastic Pirates, to see who can, and does, contribute to certain types

Table 1. Ten EU citizen engagement initiatives

No.	Name	Time	Participants and width	Cycle phase	Input type
1	Have your say	2002–present	EU citizens across the EU with online access	1–5	opinion
2	European Citizens' Initiative	2012–present	EU citizens across the EU with online access	1, 5	qualified
3	European and local elections	1979–present	EU citizens across the EU and nationally	1–5	opinion
4	Petitions to the European Parliament	1987–present	EU citizens across the EU with online access	1, 5	opinion
5	Citizens' Dialogue	2012–present	EU citizens with physical access to a dialogue session	1, 5	opinion
6	Eurobarometer	1974–present	selected EU citizens in interviews and polls	1, 5	qualified
7	Fit for Future Platform	2018–present	EU citizens across the EU with online access	1, 5	opinion
8	Conference on the Future of Europe	2021–2022	youth; EU citizens with physical access to the conference	1, 5	qualified
9	Futurium – Your voice, your future	2011–present	any EU citizen across the EU with online access	1, 5	opinion
10	Europeanization of the Plastic Pirates	2022–2025	youth and children; any EU citizen with riverine access	1–5	quantified

Current citizen engagement initiatives identified for plastic pollution policy, including information on time period, target participants, which policy cycle phase is affected, and the input type.

of policy input. Lastly, implications from the available literature on CS are discussed in terms of strengthening the citizen stakeholder group in more stages of the policy cycle for plastic pollution while providing specific recommendations on how to ensure useful and representative citizen participation in the UN treaty to end all plastic pollution. For further details, see the experimental procedures.

We identified CE initiatives through a non-exhaustive search of EU-provided entryways for citizen participation (cf. experimental procedures). The ten initiatives represent a broad range of methods for engaging citizens and provide all three types of input for policy as defined by the Better Regulation package. Table 1 provides a brief overview of the included initiatives.

Initiatives gather in a few phases
The ten identified CE initiatives demonstrated variety in geographical distribution, structure, and outcome in terms of policy input type (cf. Table 1). The initiatives spread across all levels and phases of policymaking. For instance, the general European and local elections are citizen-determined activities that have impacts on the political agenda concerning all areas of society including environmental and plastic-related regulation for a fixed time period. Differently, the Eurobarometer, which is a periodically mixed-methods poll measuring European citizen trends and topics, provides governing parties with current public opinions as context for policymaking with impacts that are more difficult to assess.
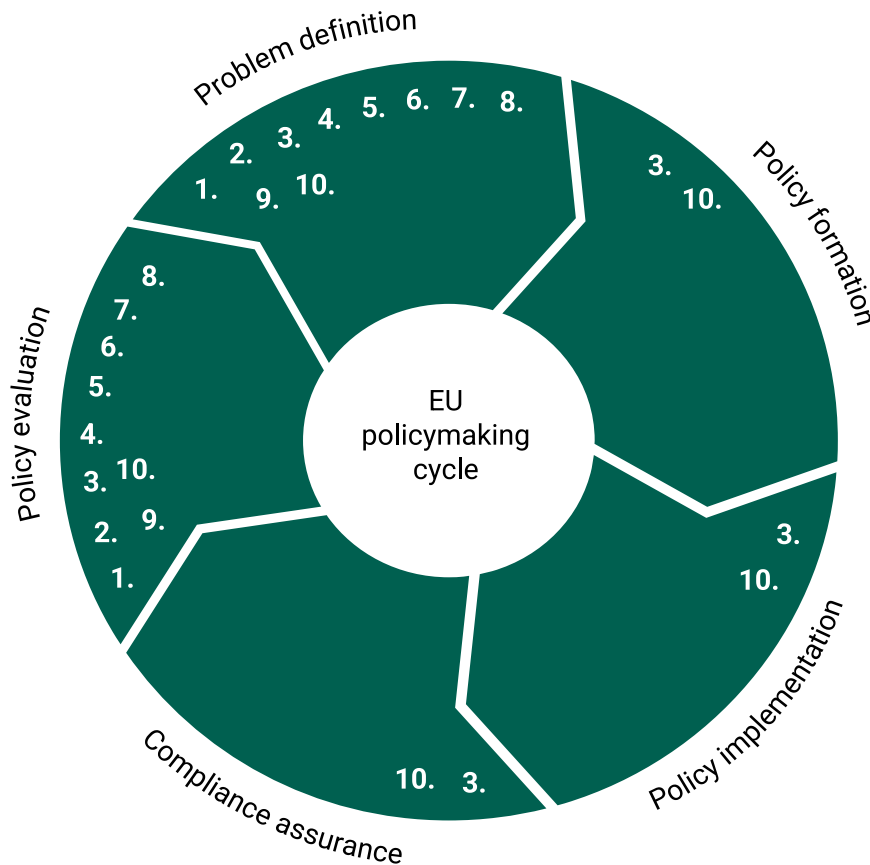
Placed on the policymaking cycle in Figure 1, representing five stages of decision-making in the EU, it is evident that the ten initiatives group together in the stages that define policy topics and evaluate existing policy.

However, two initiatives, namely European and local elections (no. 3) as well as the CS project Plastic Pirates (no. 10) manage to produce policy input for all stages of the policymaking cycle. Regarding the EC definition of evidence types relevant to policymaking in the Better Regulation package, we found that six of the initiatives produce opinions, three are categorized as qualified, and the remaining one initiative provides quantified data from the participating citizens (Figure 2).

To understand who gets to have a say in the participation initiatives, we selected three of the ten CE initiatives presented in Table 1 based on the representation of all three types of evidence input for policy and on information availability for our analysis. The three initiatives include the "Have your say" portal, the European Citizens' Initiative, and the Europeanization of the Plastic Pirates, and Figure 3 provides an overview of the results of the analysis.

"Have your say" consultation platform
The "Have your say" platform is the EU's open consultation instrument sprung from the EC's proposed principles and minimum standards for public consultations in 2002.[28] In its current format, the portal allows the opportunity for all with internet access to provide feedback for every proposal. For the "Have your say" consultations, all stakeholders (divided into a ray of categories, e.g., non-governmental organization, academic institution, public authority, EU citizen, etc.) are invited to provide feedback in different stages of the regulatory process.[29] This is depicted in Figure 1, where "Have your say" has an impact on three out of the five phases in the policy cycle. The essential elaborate access to feedback throughout specific policy processes unavoidably has led to resource-intensive handling of comments, and the outcomes of the consultations have been

however, from the online platform, it remains unclear how the registered comments are implemented in the regulation process.

The CS project Plastic Pirates
The German CS initiative Plastic Pirates was originally founded in 2016, and further support from the EU was established in 2020 under Horizon Europe regarding the "Mission for Healthy Ocean, Seas, Coastal, and Inland Waters." The project organizes extensive monitoring activities approaching different aspects concerning riverine plastic litter first only in Germany, Portugal, and Slovenia and, since January 2022, across the whole of Europe.[31,32] Information on the participants in the project is available online and includes a group name along with monitoring results and geographic location. Currently, the participant list holds 1,603 names, most indicating connections to schools and some referring to specific locations. The project is oriented toward schoolteachers and youth group leaders, and thus the vast majority of the registered participants are school students.[31,33] The stated aim of the project is 2-fold: "On the one hand, the joint campaign of the ministries of education, science, and research of the three countries is intended to raise awareness throughout Europe for the importance of rivers as common lifelines, as well as for protecting our natural resources. On the other hand, the campaign aims to emphasize the importance of international research collaboration."[32] The data are continuously uploaded and displayed on an interactive map on the campaign website.

We find three research articles based on the Plastic Pirates project that use the same monitoring dataset collected by participants described as elementary and secondary school students and youth organizations[31,33,34] (cf. experimental procedures). The participant groups were voluntarily recruited through outreach activities for schools and youth organizations. The studies further point to sources of the riverine plastic litter collected and suggest policymakers implement or increase targeted mitigation measures.

The project's website underpins that according to the FAIR principles, all the project's sampling, data collection, and storage are openly accessible, supplying data for Europewide database portals to increase the impact of the collected data. Furthermore, the Plastic Pirates project seeks to support and strengthen EU policymaking by providing monitoring quantified data on policy objectives including the Marine Strategy

criticized for long delays in feedback and poor language availability.[28]

On the platform, eight consultations related to plastics were found eligible for analysis (cf. Table 2). When scrutinizing EU citizen comments reported for plastic initiatives, it became evident that transparency in terms of verifying the identity of commentators is limited at present. A considerable number of comments had apparent lobbying agendas: some registrants declared to be representatives of a company or organization, while other comments heavily referenced statements or evidence provided by the industry. One example hereof stood out regarding the roadmap and commission adoption of "Reducing Marine Litter: Action on single plastics and fishing gear." Out of the available feedback from all EU citizens, 63% of the comments originated from Italy, with all but one arguing that a ban on single-use plastics was unjustified. The remaining comments unveiled recognizable expert knowledge of the scientific aspects of the initiative, and a small portion of the comments exposed opinions in laymen's language presumably from ordinary citizens (cf. Table S1).
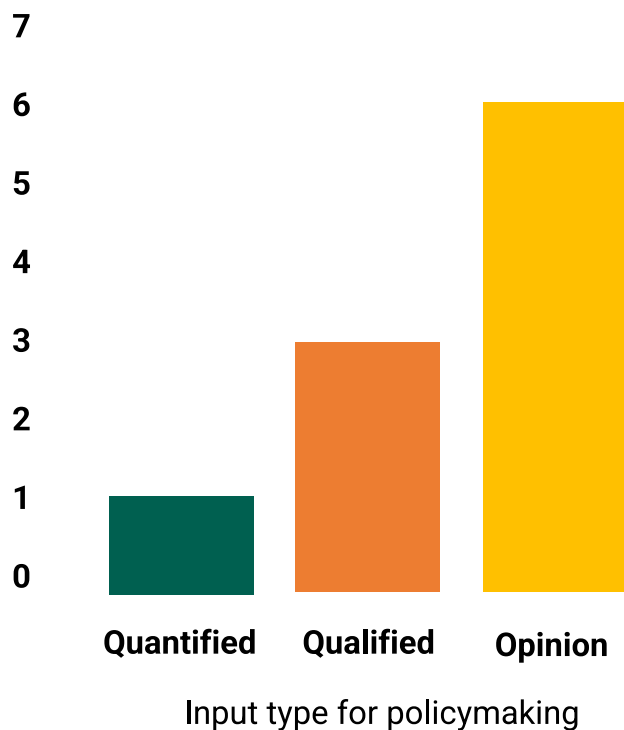
The nature of the public consultation tool is to provide a platform for the opinions of all stakeholders, including private citizens in the EU, which is what we find. It was not possible to examine the characteristics of the participating EU citizen group, in terms of identifying which type of (in terms of resources and access to insights into how policy processes work, etc.) citizen it takes to locate and contribute to relevant proposals at the platform. Consulting tool #4 in the Better Regulation framework,[30] personal views and opinions are suitable for decision-making;

Number of initiatives

Figure 2. Type of input provided by the ten citizen engagement initiatives
The ten identified citizen engagement initiatives categorized according to the type of evidence input they provide for policymaking: quantified data, qualified data, and opinions.

Framework Directive, the Water Framework Directive, and the Single-Use Plastic Directive.[32]

European Citizens' Initiative petitions

The European Citizens' Initiative is an instrument implemented in the EU in 2012 to provide access for European citizens to propose legislation directly to the EC. A plethora of requirements for the registrants and the petition itself apply for this initiative, perhaps causing few successful petitions in the past (cf. experimental procedures for further information). The online inventory of past and present initiatives reveals 94 initiatives. Searches for "plastic" and "plastics" yield four and three hits, respectively, with three repeats and one irrelevant (in terms of the topic). Of the three relevant initiatives, one has been withdrawn, one is unsuccessful in collecting enough signatures, and one is still open for support.

The one campaign currently collecting signatures is "ReturnThePlastics: A Citizen's Initiative to implement an EU-wide deposit system to recycle plastic bottles." The initiative urges the EC to propose a directive on a harmonized deposit system for taking back plastic bottles. The petition represents data that are qualified, namely that the information provided by the petition starters to the citizens in an appeal to gain signatures represents an opinionated agenda supported with varying degrees of scientific foundation.
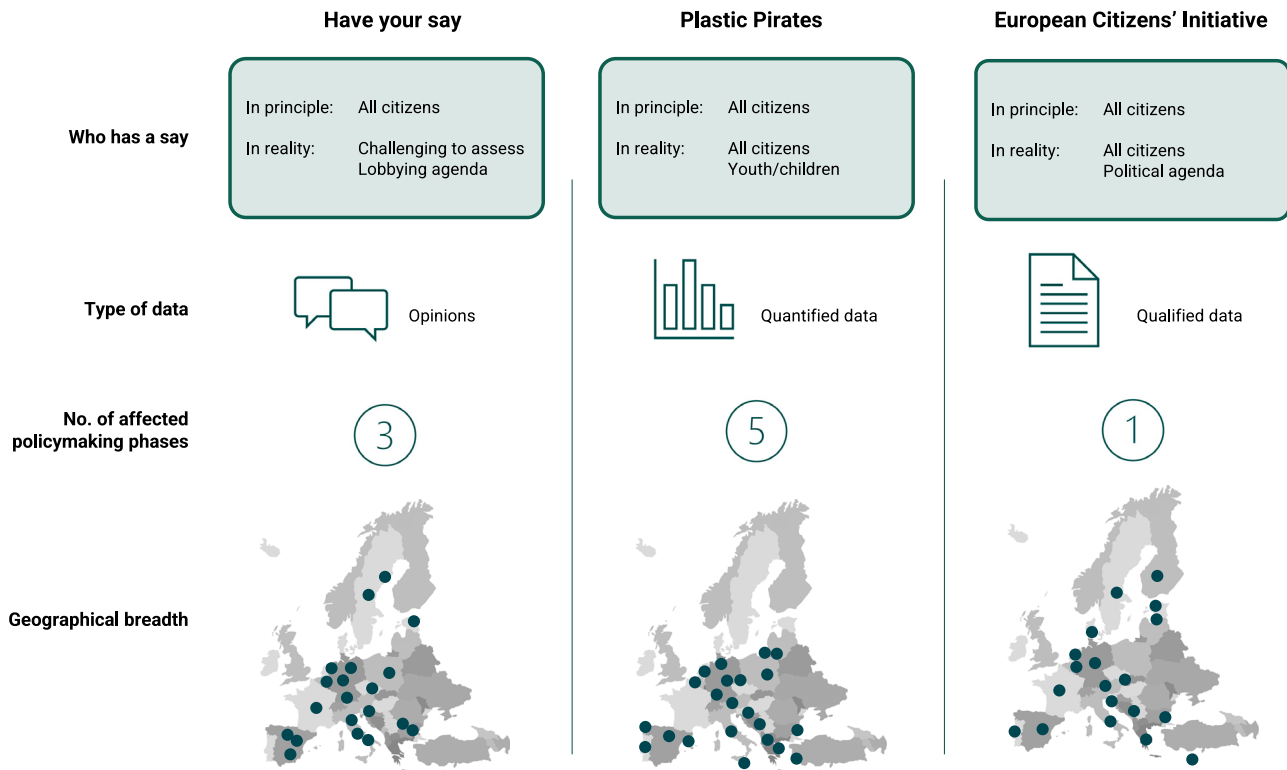
DISCUSSION

Working from the notion that citizens in the EU are concerned about the environment yet are unsure of how to participate and what impact they can have on policymaking,[28,35–37] existing CE initiatives in the EU relevant to plastic policy were analyzed. The included initiatives in this study represent a plethora of ways to engage citizens, both local and regional, and some with direct policy interaction and others with indirect implications.

Policy impact and types of input may be connected

To assess policy impact and relevance, we analyzed whether each of the ten identified initiatives was able to provide input for five different steps in the EU policymaking cycle (cf. Figure 1). Here, we see an accumulation in two phases of the policy cycle, policy evaluation and problem identification, attesting to our impression that citizens' participation may often risk constituting a mere inspiration for decision-making rather than serving as concrete input in various stages of policy development. This is an area that ought to require attention, as public trust in political institutions, including the EU, has been declining in recent years.[38,39]

We find two initiatives to consistently have a possible impact in all five policy phases, namely European and local elections and Plastic Pirates (cf. Figure 1), representing qualified and quantified data, respectively. The European and local elections are structured channels for citizens' opinions that have an impact on all policy fields and throughout all stages. The participation is, however, rather indirect, as citizens can positively affect the policy direction of the elected parties but cannot influence particular legal acts or similar. Furthermore, the voter turnout for EU parliament elections has been approximately 50% and lower for each election since 1996.[40] Secondly, the Plastic Pirates project is an EU-supported CS project operating at local and regional levels producing scientific data for monitoring purposes that too can contribute directly as evidence in all policy stages. Because of the scientific method (e.g., by employing harmonized research protocols for collection and registration), a particular individual's impact is not personal or opinionated but rather takes form as a collective effort to support evidence-based policy formation. The power of impact lies primarily in how the data collection occurs in terms of data quality and verifiability.[26,41–43] Thus, while these two mechanisms have the potential for policy impact across the policy development cycle, effectively, the number of citizens participating, and the direct power of the participation, may still be limited. Consequently, although both initiatives influence all policymaking phases, the CS Plastic Pirates project stands out with a significant direct impact on the local and regional levels.

It appears that participation in the form of opinions may end up being held from impacting policy in more than an inspirational manner. Even though the Better Regulation toolkit guidelines equal the contributions of quantified data, qualified data, and opinions[15] as evidence for policymaking, this study's results point to the fact that citizen participation in public consultations overall is unrepresentative in terms of presence (cf. Table 2). Similarly, a study by Clausen et al. found the citizen stakeholder group to be "silent" in the public consultation on a similar

Figure 3. Results overview of the three citizen engagement initiatives
Results of the analyses of the three initiatives: the "Have your say" platform, Plastic Pirates, and European Citizens' Initiative.

proposal on plastic in the "Have your say" portal.[44] This is illustrated in our findings where six of ten citizen initiatives were categorized as opinions (cf. Figure 2) while all but two initiatives gathered in the evaluation and development phases of the policy cycle (cf. Figure 1), including the "Have your say" consultations. This is particularly interesting as the EU insists on putting public consultations on a high pedestal as one main pillar of citizen involvement.[30] While we find that the consultation system upholds the standards of highly organized input, the claims of high levels of transparency and accessibility are not reflected in our findings as well as in other recent literature.[12,28]

In this context, for an impactful involvement of citizens in the UN treaty, we recommend: building easily accessible databases of CE activities that disclose all aspects of the initiatives including policy impact; ensuring communication with citizens to increase the sense of participation, purpose, and empowerment; and demanding transparency in data collection to give power to citizen initiatives that otherwise risk losing legitimacy.

Current plastic policy calls for quantitative input
In line with existing literature, our results suggest that plastic policymaking calls for quantitative data input,[45,46] for instance with the recent and direct applicability of the Plastic Pirates-generated data used for evaluation of the EU Single-Use Plastics Directive.[34] This study further suggests that the more quantitative data provided, the more evident the policy impact appears. For instance, no information is provided to the participants on how the contributions to the "Have your say" consultations will

impact the proposals in question, and therefore any direct impact is difficult to confirm.[28] Interestingly, the European Citizens' Initiative promises an in-person consultation with the EC if the campaign reaches one million signatures, but the success rate is nevertheless vanishingly small. In the first 9 years of the initiative's existence, 102 initiatives have been put forward, six have succeeded in collecting the required one million signatures, and only one initiative has had its proposal translated into legislation by the EC.[28] This demonstrates that even though the prospect of directly consulting with the EC is, in theory, obtainable, this is rarely the case, and thus these petitions may not provide an effective format for participation in practice. Lastly, we find the Plastic Pirates' data collections applied directly in published literature and as an evaluation instrument for plastic policy. Although scientific literature does not translate into policy change, it gives a seal of approval and feeds into the collective knowledge base on plastic pollution, as seen in the research article by Kiessling et al., "Schoolchildren discover hotspots of floating plastic litter in rivers using a large-scale collaborative approach."[33] This tendency echoes expert analyses of the participation efforts of the EU[28] and may, in this case, be due to the inherent scope of the plastic crisis, where critical knowledge gaps demand large amounts of monitoring data to obtain the full picture of the state of the environment and to measure policy impacts.[46]

Initiatives in various constellations undoubtedly contribute to policymaking in diverse ways, and a collective inventory of participation channels offers a holistic approach to ensure the

Table 2. Eight proposals on the "Have your say" platform

No.	Proposal name	Proposal status	EU citizen comments (% of all)
1	Draft act: Food safety – recycled plastic in food packaging (updated rules)	closed; January 18, 2022	5.5%
2	Draft act: Single-use plastics – reporting of data on post-consumption waste of tobacco products with plastic filters	closed; October 20, 2021	33.3%
3	Draft act: Plastic & other waste unintentionally fished from EU seas (monitoring & reporting guidelines)	closed; October 15, 2021	25%
4	Roadmap and commission adoption: Reducing marine litter: action on single use plastics and fishing gear	closed; January 12, 2018, and July 25, 2018	roadmap: 17.9%; commission adoption: 22.5%
5	Draft act: Recycling – EU rules on calculating, verifying and reporting data on separate collection of single-use plastic bottles	closed; June 17, 2021	2.4%
6	Call for evidence: Microplastics pollution – measures to reduce its impact on the environment	closed; January 18, 2022	22%
7	Roadmap: Policy framework on biobased, biodegradable and compostable plastics	closed; October 27, 2021	6.2%
8	Roadmap: Circular economy – new action plan to increase recycling and reuse of products in the EU	closed; January 20, 2020	7.7%

The eight proposals relevant for plastic policy on the "Have your say" portal and the percentage of EU citizen comments. The data were gathered for past available proposals until May 15, 2022.

inclusion of many citizen segments. Yet, our findings suggest that current participation in EU plastic policymaking tends to be dominated by contribution in the form of opinions, which are difficult to convert to policy impact in practice.

Consequently, we recommend for negotiators involved in the development of the UN treaty to systematize and harmonize inputs of citizen initiatives to increase application and policy uptake of, e.g., CS data, and to build awareness and share best practices and funding, e.g., by building partnerships between all key stakeholders including governments, NGOs, civil society, etc.

CS for the plastic treaty

Recent scientific publications point to one thing in particular when addressing the necessary preconditions for the successful development of the UN plastic treaty: the need for scientific and comparable data on plastic pollution. Subramanian underlines that if there is no baseline for plastic pollution at a global scale, it will be incredibly difficult to design and employ policy actions—you cannot manage what you cannot measure.[46] Thompson et al. call for data to cover all relevant stages of plastics production, consumption, and end of life and insist that appropriate political interventions must rely on scientific evidence.[47] In this context, CS represents a tool that has the potential to fill in major knowledge gaps at a national and global scale while also engaging citizens from diverse communities in setting a political agenda, as we also see in the above analysis of the Plastic Pirates project.[24,41,48]
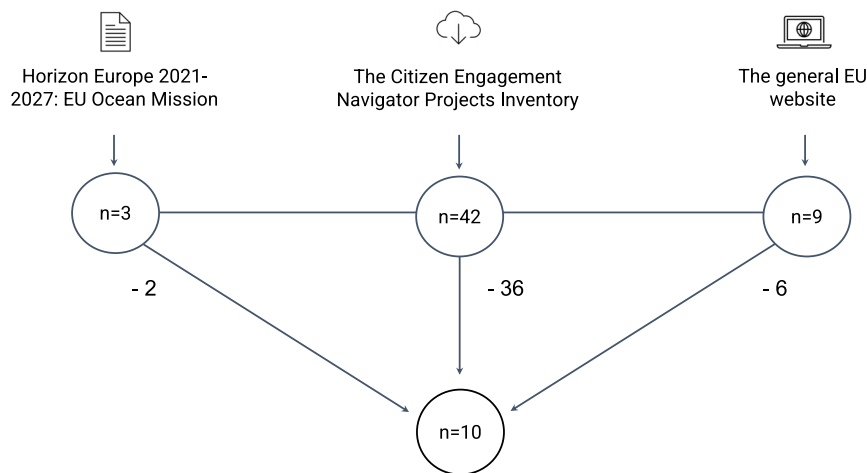
Naturally, there are examples of CS projects that are inadequate for policy in terms of relevance or quality; nevertheless,

several publications and reports on the subject have by now established that CS, through unique data collected across places and time that may otherwise be limited to traditional monitoring schemes, can underpin and directly impact all policy stages of environmental policymaking.[22,26,41] It is thus relevant to examine some of the central parameters ensuring applicability in plastic pollution policymaking.

Common accessibility of data is critical for the effective use of CS data and a common foundation for supranational measures to tackle plastic pollution, e.g., under UN governance. Standardizing and aligning methodologies with global methodologies and establishing international agreements on where to openly share data is one first step in this direction.[21,49] The Earth Challenge data integration platform is an example of such an open and emerging data network encompassing CS data from three large databases: the European Environmental Agency's Marine LitterWatch, the National Oceanic and Atmospheric Administration's Marine Debris Monitoring and Assessment Project, and the Ocean Conservancy's Trash Information and Data for Education Solutions Database.[50]

Another key factor for increasing policy uptake is government support for CS projects including funding but also in terms of collaboration on defining policy-relevant objectives.[26] However, highly constrained types of projects may risk limiting citizens' ability to influence why and how the science projects are conducted if this is not put to attention.[27,51] Particular consideration should be paid to this issue since the type of CS projects initiated by governmental institutions, which this paper focuses on, are inherently characterized by a top-down approach. Cocreation of objectives and design by all stakeholders including governing

Horizon Europe 2021-2027: EU Ocean Mission

The Citizen Engagement Navigator Projects Inventory

The general EU website

n=3   n=42   n=9

- 2   - 36   - 6

n=10

der "Horizon Europe 2021–2027: EU Missions,"[16] and the Joint Research Center's database of current projects in the EU concerning CE called The Citizen Engagement Navigator.[54]

EU policy cycle and types of information

Based on the immediate description and the intended aims for impact in a policy setting, the identified CE initiatives were distributed throughout five stages of policymaking (cf. Figure 1). This was done to underline the current access points for citizen influence regarding decision-making in the EU. The five stages include (1) problem definition, (2) policy formation, (3) policy implementation, (4) compliance assurance, and (5) policy evaluation. The ten initiatives were analyzed with attention to the direct pertinence of the initiative output and general available information.

The type of information that each of the ten initiatives provided for policymaking was analyzed with reference to the suggested input categories in the EC's Better Regulation toolbox, "Tool #4. Evidence-informed policymaking": quantitative data (defines), qualitative data (describes), and opinions (personal views).[15]

Analysis of who has a say

Three different forms of initiatives for CE, which the EU is currently employing related to plastic policy, provided an understanding of who is heard and what type of information the involved citizens are contributing to the regulatory process and presented different approaches to citizen involvement. All ten CE initiatives were scrutinized in the process of selecting only three for further analysis, and the inclusion criteria consisted of whether data were fully accessible to us and whether the elected initiatives represented all three types of input. This process resulted in EC public consultations via the "Have your say" platform, the EU-supported CS project Plastic Pirates, and EU-facilitated petitions via the European Citizens' Initiative. To determine who provides data, the specific participants were identified based on the registration in each case.

For the "Have your say" platform, the above analysis strategy means that we looked at legislation concerning plastic with a focus on those currently accessible online and have been closed for feedback to gain appropriate comparisons. The search strategy captured all consultations resulting from the search terms "plastic" and "plastics" presented in Table 2. All comments by EU citizens were read and shortly summarized (cf. Table S1) to create an overview of the information submitted as feedback.

For the Plastic Pirates project, we identified the types of participants using the project website and further details provided in the published scientific literature using data collected from the project. To identify relevant literature, we searched the databases Web of Science, Scopus, and Google Scholar using the search term "Plastic Pirates" to capture relevant peer-reviewed literature on the project's outcomes. We included studies that used results from the Plastic Pirates data collections and excluded others.

The European Citizens' Initiative is an online petition platform facilitated by the EU and allows EU citizens to formulate initiatives that, in turn, can request that the EC propose new laws. It is necessary that the petition adheres to regulation (EU) no. 211/2011 of the European Parliament and the Council,[55] laying out the ground rules for the content of a proposed initiative. To have the EC's attention, the proposition requires the backing of one million signatures from EU citizens of at least seven different EU countries within 12 months.[56] Once the required signatures are acquired, the project leaders have the opportunity

bodies and citizens from vulnerable communities may help remedy this concern.

Lastly, upscaling of experiences and appreciation of CS as a valuable source of policy information should be fostered at more governance levels than just the local, where most projects seem to operate. National and intergovernmental data and statistics communities can gain access to important monitoring data if a link between the horizontal governance levels can be established along with instructions and knowledge sharing on the applicability.[25]

To ensure relevant and applicable citizen input, we recommend that the UNEA provides equitable access to more stages throughout the policy process, e.g., by building enabling environments, ensuring access to funding, and deliberately designing projects for policy needs and input in many or all policy phases. We furthermore recommend that lessons learned from existing examples of successfully applied CS for policy projects in other fields, e.g., marine policy by the European Marine Board, should be considered and include prevailing scientific recommendations and policy briefs, e.g., Fraisl et al.,[24] Nelms et al.,[52] Ammendolia and Walker,[48] and Turbé et al.[26]

EXPERIMENTAL PROCEDURES

Resource availability
Lead contact
Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Nikoline G. Oturai (nbango@ruc.dk).
Materials availability
This study did not generate new unique materials.
Data and code availability
This paper analyzes existing, publicly available data. Data from the "Have your say" portal analysis are found in Table S1. This paper does not report original code.

Identification of CE initiatives
To carry out a comprehensive overview of current CE initiatives under the EU, three different sources of information on CE projects were searched following the steps depicted in Figure 4. For the sake of relevance and scope, the time period for inclusion of initiatives was set to cover those currently running (as of July 2022) and those that had or could have a plastic focus. These activities were identified by a non-exhaustive scrutinizing of the general EU website under "Participate, interact and vote in the European Union,"[53] an examination of the activities in "Ocean Mission: Restore our Oceans and Waters by 2030" un-

to present the initiative in front of the EC as well as at a public meeting at the European Parliament. All past and present proposed initiatives appear in an online database where we used the search terms "plastic" and "plastics" to find relevant initiatives for the analysis of who can participate in this type of initiative and what input for policy it constitutes. We included initiatives that were directly related to plastics in the description aim.

AUTHOR CONTRIBUTIONS

Conceptualization, N.G.O., K.S., and S.F.H.; methodology, N.G.O., K.S., and S.F.H.; investigation, N.G.O., K.S., A.H., T.M.R., and S.F.H.; writing – original draft, N.G.O.; writing – review & editing, N.G.O., K.S., D.F., A.H., T.M.R., S.S., and S.F.H.; visualization, N.G.O.; supervision, K.S. and S.F.H.; project administration, N.G.O.; funding acquisition, K.S.

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