Who talks about climate, peace and security? A social media analysis to identify key actors

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Abstract

Uncovering key actors within a policy network provides pathways for engagement, consensus-building, partnership development, and understanding the diffusion of knowledge in a given debate. Given the unprecedented scale of the climate emergency, the emerging field of climate security has rapidly gained centrality in academic and policy fora, as well as in the public debate. Yet, a systematic analysis of the main actors engaged in this space is missing. This study draws from digital methods and network analysis techniques to employ a method for identifying relevant actors, focusing on Twitter (now X) from 2014 to 2022, with the objective of spotting the major actors driving public discussions around climate security. The research also demonstrates how institutions can position themselves within such issue networks through a case study of the Consultative Group on International Agriculture Research (CGIAR), a global research-for-development organization that has recently positioned itself in the climate security community. Results reveal that the climate security debate on social media is predominantly institutional, with research bodies and international organizations as central elements. While CGIAR is a relatively new actor, it is already centrally located in the network, maintaining strong connections with other major players, which places it in a strategic position to enhance its influence and reach. Understanding this discursive landscape is crucial for identifying opportunities for effective engagement, partnership, and positioning in such an increasingly salient field of research and practice.

Introduction

Policy networks represent the interactions of public and private actors who gather around a common policy issue or goal [1]. These networks can be transnational, national, or issue-based, and play a significant role in agenda-setting. Uncovering the main actors within these networks, particularly in relation to new and emerging topics, can provide pathways for engagement, for strengthening a common vision or consensus, for building strategic alliances and partnerships, and for understanding both the diffusion of knowledge and the gaps in a given debate [1].

To explore the actors driving a policy network, actor mapping proposes a "visual depiction of the key organizations and/or individuals that make up and/or influence a system, as well as their relationships to a given issue and to one another" [2]. While often misinterpreted for stakeholder analysis, actor mapping intends to explore the connections among actors, rather than their ability to influence specific projects, policies, or outcomes. In fact, actor maps support understanding of entities and their roles within a networked system and assessing the level of engagement and strength of connections between them [3,4].

Actor maps also enable systematic debate observation, reflexive participation by existing participants, and provide the opportunity for new groups aspiring to join the debate [5]. More specifically, this approach helps identify opportunities to build new relationships and explore unknown connections, as well as possible entry points for potential intervention and engagement. Institutions can leverage actor mapping to support strategy development and to evaluate influence [2]. In seeking to enter an issue network and establish influence, actor mapping also allows to identify with whom it would be timely and fruitful to build relationships and partnerships to propagate information to other relevant parties in the network [6].

Among the potential strategies to identify key actors in an issue network, social network analysis enables discovering underlying patterns that may be overlooked by using traditional social-scientific research methods [7]. A social network structure emerges through the establishment of connections (referred to as "links," "ties," or "edges") among social actors such as individuals or organizations [8].

In social media, studies that apply a social network analysis perspective, attention is redirected from individual characteristics to the interconnected relationships linking social entities [9]. This is because, within social networking platforms, users construct networks by engaging with fellow users through connections and the exchange of information. These digital spaces enhance the opportunities for connecting with likeminded strangers despite spatial or temporal dispersion [10] and offer effective means of disseminating information dynamically [11]. As such, social network platforms not only serve as spaces for interaction but also as structures that afford specific types of sociality and information flow. This introduces an additional layer of complexity to social network analysis, since it necessitates understanding the specific affordances of the studied platform in shaping the social interactions of its public [12].

In digital actor mapping, the network structures of social media platforms comprise users and the connections formed as they engage in interactions, such as follows, mentions, and replies to one another [9]. There is extensive literature that has applied social network analysis to communications and social media data around assorted topics. For instance, to assess networks of innovation diffusion [13]; to explore inter-organizational collaboration and collaborative governance structure [14]; to understand conspiracy networks and how controversies are diffused in digital spaces [15,16]; and to map issue networks around elections or political events [17]. While

relying on diverse network analysis metrics and frameworks, all such studies aim to demonstrate that real world actions can be inferred based on the connections and activities in social media [11].

This study builds on an existing typology of opinion leaders on Twitter [18] to employ digital actor mapping to the field of climate security, which emerges in the 2000s, when persistent and rapid environmental changes became a more prominent concern for the international community [19]. In less than two decades and with the climate emergency at an unprecedented scale, discussions around the peace and security implications of unfavorable climate change impacts have gained centrality in academic circles, policy fora, platforms, and processes, as well as newspapers and social media [20,21].

This has been accompanied by the proliferation of several international and regional actors engaging, influencing, and working in this space and the creation of a community of practice on climate security that includes leading research institutes, think tanks, international organizations and United Nations (UN) agencies [20]. For instance, the UN Secretary General, António Guterres, has referred to climate and environmental changes as a "crisis multiplier," which in contexts where coping capacities are limited and there is a high dependence on natural resources and ecosystem services, can "complicate efforts to prevent conflict and sustain peace" [22]. At the same time, world leaders have increasingly acknowledged the adverse effects of climate variability and change on human lives and societies, including the potential for threatening peaceful community and social relationships. Frequently cited examples include the violent confrontations between farmers and herders in the Sahel, localized conflicts over water sources in the North Africa and Middle East (MENA) region, as well as widespread support and recruitment by non-state armed groups of populations hit by droughts and other extreme weather events in East Africa, and even

some parts of South-east Asia and Latin America – see for instance Broek & Hodder [23] and Läderach et al. [24].

Reflecting the growing policy relevance and perceived salience of the issue, the Intergovernmental Panel on Climate Change (IPCC) included for the first time a chapter on human security, with a sub-section specifically focusing on the possible risk of violent conflict, in the Fifth Assessment Report released in 2014 [25]. Most recently, the IPCC Sixth Assessment Report made a further step forward, expecting climate change to become a "representative key risk" for future peace and stability if climate action is not urgently taken [26].

Attention to climate change as a prominent risk to peace and security is also reflected in the work of many governmental entities and international, regional and national agencies and stakeholders that, over the past years, have increasingly prioritized these issues in their policy and programmatic agendas. For example, at the United Nations (UN) level, the establishment in 2018 of the Climate Security Mechanism (CSM) has been pivotal for embedding climate security analysis and action more systematically into the UN Secretariat's work. At the same time, the African Union (AU)'s own Peace and Security Council (PSC) issued, in March 2021, an unprecedented communique, stressing the need to increase the capacity of member states to identify and proactively respond to these compounded challenges. On a more of a regional level, the Economic Community of West African States (ECOWAS), the European Union, and the Intergovernmental Authority on Development (IGAD) have step up their efforts to address the possible security implications of climate change impacts, including embedding conflict-sensitive language into their climate change measures and strategies.

Nevertheless, while this debate has gained increased salience in research, policy and practice, a comprehensive and systematic analysis of the main actors engaged and working in the

climate security space is missing. This is particularly true when considering that the few strides made so far to map these actors are qualitative in nature and have regional coverage – see, for instance, Destrijcker et al. [27]. Identifying climate security actors is particularly challenging, as the impacts of climate change can simultaneously undermine the security of individuals, communities, states, ecosystems, as well as the international system [28]. As such, a broad range of entities and organizations may be concerned and contributing, albeit implicitly, to preventing and mitigating climate-related security risks [29]. Given the absence of a consensual definition of climate security actors and a defined framework in which they operate, social media platforms present a dimension where the narratives and actor dynamics on the subject can be systematized through analysis of publicly available content and interactions. While actors with a research or operational portfolio explicitly referring to climate security may be easier to identify, other relevant player addressing specific components of the nexus (for instance, food insecurity or natural resource management) and that have just entered this space might go under the radar. This is where social media data can contribute, by offering insights into climate security actors by providing information on how often actors are brought into the online debate, by whom, and how they respond. For example, mentions serve as a metric of prominence, revealing which individuals or institutions are frequently referenced and, therefore, central to the climate security conversation. This metric makes it possible to evaluate whether key players in the network are acknowledging each other and amplifying messages. These layers of information allow researchers to map out the dynamics of authority and engagement in the digital space, providing a clearer picture of which actors dominate the climate security discourse, their characteristics, as well as how they interact within the broader network.

This paper contributes to identifying relevant actors engaged in the digital climate security landscape, with the overall objective of providing some preliminary insights that enable more integrated approaches to the issue and potential gaps in engagement that should be addressed. We conduct a data-driven actor mapping analysis based on climate security content generated on Twitter since 2014. Considering Twitter's historical significance as a digital forum for information exchanges and dialogue [30], the main aim is to characterize an ecosystem of actors engaging in public conversations around the topic.

In addition, to show how such an approach can be useful for institutions aiming to position themselves within a particular issue network, we present a case study of the Consultative Group for International Agricultural Research (CGIAR), a global research-for-development organization. Through the work of CGIAR FOCUS Climate Security , a research team with the Alliance of Bioversity International and CIAT, CGIAR has been leading research on climate security. Born as a spin-off of the Climate Change, Agriculture and Food Security (CCAFS) research program in 2019, the team has rapidly expanded, with a current project portfolio of more than six million USD per year and more than sixty researchers working in about twenty five countries and based in six regional hubs (East Africa, West Africa, Central and Southern Africa, Middle East and North Africa, Latin America, South and Southeast Asia). These hubs are strategically located in climate and security hotspots where Humanitarian and Peace actors have their own regional offices and are leading research and policy advocacy work in many fragile and conflict-affected areas. In the past half a decade, CGIAR FOCUS Climate Security has sought to position itself as a key actor in the climate security space, interacting with and strengthening existing networks of institutions and experts.

This paper is structured as follows. Initially, the introduction sets the foundation for the study, establishing the scope and significance of the research. This is followed by a review of the relevant literature, offering a comprehensive understanding of existing knowledge and methodologies used for social media-based actor mapping. The subsequent section details our research methodology, including the processes involved in creating the dataset and conducting network analysis. The Results section presents an overview of the climate security debate on social media, followed by an examination of actor interactions and key influencers, concluding with an assessment of the role of CGIAR in these discussions. The Discussion section critically reflects these findings, contextualizing them within the broader discourse on climate security. Finally, the paper concludes by synthesizing the main insights and their implications for the climate security scholarship literature.

Data and methods

While qualitative, participatory methods have been documented for actor mapping exercises at a project scale [2] this analysis proposes a data-driven approach based on the digital methods epistemology, which seeks to explain social phenomena through online dynamics [31], to map the global landscape of climate security.

For this purpose, we employ social network analysis (SNA) to identify the most prominent actors within a particular topic network in social media. A topic network in the context of social media refers to a collection of content centered around a specific subject, established by utilizing keywords or hashtags for selection purposes [9]. This network encompasses various permutations of hashtags and keywords on platforms like Twitter.

In particular, we use historical data collected from Twitter (data was collected through its API, before the platform's name changed to X). As the platform has the characteristics of both a social network and an informational network, it is a relevant space for the dissemination of information [18]. Due to its interactive and networked nature, Twitter facilitates the formation of communities of people and entities directly connected through underlying relational networks [9,15].

SNA is an appropriate methodological choice for this study, not only because it has been employed extensively in social media studies, in particular those that address the issue of uncovering important of influential actors in networked platform data [6], but also because it enables the analysis of inter-connectivity, in which nodes represent the members of a particular social network, and the edges represent the connections between them [3,4]. Such connections can be assessed based on various affordances of the platform, both in relation to content, such as co-hashtag networks [32], and in relation to users, such as account follower networks [7,33] or interaction networks [17,34]. User-hashtag networks map the entities disseminating content around particular topics; account follower networks display the reach of particular users; interaction networks present the connections between users who interacted with each other via mentions, retweets, replies and quote tweets.

This study follows the latter approach, in which each link represents an actual exchange of information that has taken place, regardless of whether accounts are acquainted to each other in any dimension [6]. Existing studies recognize that mentions and replies are types of interactions that are "closely related to individuals and micro-level communication" [15]. In addition, by focusing our data collection on content specifically related to climate security, we only record

connections that are relevant to our topic of interest. This way, we were able to generate an overall network of users who interacted with each other within the context of climate security debates.

In the same line as Laflin et al. [6], in the pursuit of understanding user engagement with specific subjects, the initial approach involves identifying individuals who share tweets containing predefined hashtags. Notably, the subsequent analysis of these networks hinges solely on their structural properties, with no further consideration given to the actual content of the tweets. This topological perspective underscores the significance of connections and patterns within the network itself, illuminating the interactions surrounding the chosen topic.

Leveraging social media data to identify key actors driving a particular conversation is helpful to determine communication patterns, the diffusion of information, and the flow of opinions that define dominant discourses. Rehman et al. [18] denominate the most influential users in a particular conversation as “opinion leaders” and defend the significance of identifying them, as these users have an important role in the spread of information within a thematic network. This significance is reinforced by the current context of two-step flow communication [18], in which information is no longer directly transferred from mass media to the general public, but rather, is most often first interpreted by opinion leaders. These prominent users can affect other community users based on their status, including influencing organizational behaviors and activities, as well as the opinion of other groups [35]. At the same time, while influential people or entities are critical factors affecting information cascades, they comprise a minority within a broader community [7], which further supports the importance of identifying them.

Dataset creation

Our dataset for analysis was created through a snowball sampling approach to extract data from Twitter [36]. The initial query included keywords and hashtags related to climate security in English, French, and Spanish, namely "climate security", "sécurité climatique", "seguridad climática", #climatesecurity, #sécuritéclimatique, and #seguridadclimática. The dataset was created by scraping the Twitter Academic API using the tool 4CAT [37] and filtering for tweets containing the terms. In this first dataset, 10,139 unique hashtags were identified, of which 2,167 appeared two or more times. After a qualitative assessment, 54 hashtags were considered relevant to the field of climate security. To expand the dataset, a second scraping step was conducted based on the hashtags identified from the first round, taking into consideration the Twitter API query limit. Three requests were made to the API via the 4CAT tool [38], and the 54 relevant hashtags were included in the query. The data was filtered from 1 January 2014 to 9 March 2022, with the output limited to two million tweets. After the second data extraction step was completed, the data collection phase was considered complete. The three output CSV files were then imported to R Studio [39], merged, and duplicates were removed. The complete and detailed process of dataset creation, as well as its formal description, are presented in a data article [40].

A limitation of creating a dataset using hashtags through snowball sampling is the potential for noise within the collected data. Hashtags can be used in inconsistent ways, leading to the inclusion of off-topic content in the dataset. Additionally, hashtags can be co-opted by different communities or individuals for purposes that diverge from the intended focus of the study. Even conducting a careful manual selection and refinement of hashtags, the dynamic nature of social media conversations makes it challenging to fully eliminate noise from the dataset [41].

The raw dataset consists of 308,429 unique original tweets, retweets, and replies. After qualitatively analyzing the hashtags, all tweets containing the hashtag #NewClimateWar were removed, since they are related to marketing campaigns and conversations about a book [42], falling outside the scope of this analysis. Moreover, while the concept of "climate wars" appeared in some early discussions on climate security, it was highly problematized by prominent scholars in the field due to its tendency to militarize the issue of climate change, thereby falling in disuse – see, for instance Theisen, Holtermann & Buhaug [43]. At the end of this process, the working dataset comprised 259,470 original tweets, retweets, and replies.

Social network analysis

In Twitter conversations, users often tag other accounts by utilizing the '@' symbol followed by the respective profile username. This feature creates a network that connects users who are mentioned and those who mention others. The analysis of the network of Twitter mentions can offer valuable insights into the online discourse surrounding climate security. By exploring the relationships among users who mention one another in their tweets, we can identify key actors and communities within the conversation. The network can reveal patterns of information flow, highlighting which users are central to the conversation and which are more peripheral and can provide a valuable tool for analyzing the social and informational aspects of the discourse around climate security within the Twitter sphere.

The choice to focus on mentions as a specific type of interaction on Twitter, rather than including retweets, quotes and replies was due to the unique insights mentions offer into direct engagement between actors. Mentions represent intentional efforts to involve other users in the conversation and are more deliberate than retweets, as they involve one user explicitly addressing

or acknowledging another, signaling a form of direct communication or recognition. The object is analyzing originally written content, which retweets do not represent. Retweets primarily signify content amplification [44], rather than the creation of new tweets or the establishment of direct dialogue between users.

To construct the Twitter mentions network, we processed the data using RStudio [39], focusing on original content and excluding retweets and replies (for a total of 66,775 original tweets). Further filtering removed tweets that did not mention any accounts, resulting in a final dataset comprising 28,392 tweets created by 8,148 unique authors, encompassing 56,572 mentions to 13,395 distinct accounts (note that a single tweet may mention multiple accounts). We created the nodes and edges tables, exporting them in CSV format.

Social network analysis was conducted using Gephi [45]. We calculated statistical metrics for the mentions network: the average degree, the betweenness centrality, and the modularity class. The modularity class [46] was determined, to identify communities of users who interact more frequently with one another than with external parties. The classification of profiles within our dataset unveils how they tend to engage in conversations about climate security with one another.

Such an investigation into social goes beyond a mathematical endeavor; it is a visually rich exploration of interconnected user dynamics [4]. Embracing this visual dimension leads us to a deeper understanding of the intricate relationships between distinct categories of actors that participate in climate security debates. By navigating this ever-changing digital landscape, we empower ourselves to navigate the evolving conversations surrounding climate, peace and security, unraveling the intricate web of connections in this critical domain.

Identifying the key actors in a Twitter mentions network

Building upon prior research [18], we classified the roles of users within the climate security Twitter mentions network. As discussed previously, Rehman et al. [18] propose a typology of influential users. Five types of key users may emerge in a mentions network: (i) influencers receive a high number of mentions and mention others frequently; (ii) conversation starters receive a high number of mentions but mention others infrequently or not at all; (iii) active engagers mention others frequently but are not mentioned as frequently in return or are mentioned only a few times; (iv) network builders connect two or more influencers within the network; and (v) information bridges act as a link between an active engager and an influencer. Within this typology, influencers, conversations starters, network builders and information bridges are considered the most significant "opinion leaders," but we prefer to call them key actors in this paper, as the climate security debate is still emerging and there is not yet a clearly defined, established leadership within this space.

To identify the most relevant actors within the climate security Twitter mentions network, we considered the appropriate centrality metrics as proposed in Rehman et al. [18] to determine the five most significant influencers, conversation starters, active engagers, network builders, and information bridges across the dataset.

Assessing CGIAR's engagement with relevant actors in the climate security Twitter mentions network

To evaluate CGIAR's interactions with relevant actors identified in the previous analysis, an additional step was taken to locate CGIAR's presence within the broader network. A list of

CGIAR's Twitter profiles was compiled (see S1 Table), and these accounts were searched within the entire mentions network. A total of 38 accounts were identified.

A union of ego networks was constructed using Gephi filters [45]. Ego networks refer to the social connections of a specific individual or ego and provide crucial insights into the social dynamics of CGIAR profiles. To visualize the union of ego networks, all accounts were initially organized in a circular layout. Then, exclusively the CGIAR accounts were fixed in this layout. Subsequently, the ForceAtlas 2 algorithm [47] was applied, causing the unfixed accounts to gravitate towards the proximity of the fixed accounts to which they were most connected. This visualization offers a comprehensive representation of the connections and relationships among CGIAR profiles and sheds light on their centrality within the climate security community.

Results

Our dataset comprises 66,761 original tweets, 185,392 retweets, and 7,317 replies. The monthly timeline of climate security tweets from 2014 to March 2022 is presented in Fig 1. The year of publication of the IPCC's Fifth Assessment Report (AR5) was selected as the starting point for data collection as a milestone in the development of both the study and practice of climate security [48]. As can be seen, this field has rapidly evolved, moving from the margin of Twitter conversations to become a more prominent and salient topic. The significant increase in the number of tweets in 2018 coincides with the adoption of the UN's Sustaining Peace Framework, an overarching conceptual framework for building peace, linking humanitarian action and peace and security with development and human rights responses.

Fig 1. **Climate Security tweets time series (2014 to 2022).** Tweets, retweets and replies are aggregated by month.

At the same time, the exponentially high number of tweets in 2021, particularly towards the end of the year, refers to the animated international discussion following the UN Security Council (UNSC)'s rejection of a thematic resolution addressing the security of climate impacts for peace and security – see Buhaug, de Coning & von Uexkull [49].

Fig 2 provides a visual representation of the climate security mentions network on Twitter, capturing the intricate web of connections encompassing the 56,572 mentions derived from our dataset. The network comprises 19,217 nodes and 33,773 edges, with each node representing a user involved in the mentions, either as a mentioned or mentioning account. Notably, a single tweet may contain mentions of one or multiple accounts. The size of each node corresponds to its degree, that is, the number of connections with other nodes.

Fig 2. **Network of Twitter mentions in conversations about climate security from 2014 to 2022.** The illustration provides a zoom on the center and most dense part of the network.

The network demonstrates a modularity value of 0.707, indicating a strong community structure, with the network divided into 1,204 distinct clusters. A modularity value closer to 1 suggests that connections are denser within clusters than between them, highlighting the presence of well-defined communities [46]. Furthermore, the color assigned to each node reflects its role on the network, based on the type of user that the node plays in the network: regular users are colored gray, influencers are orange, network builders are yellow, information bridges are blue,

conversation starters are red, and active engagers, green. The ForceAtlas 2 layout algorithm [47] employs a force-directed approach, simulating attractive forces between connected nodes and repulsive forces between all nodes, resulting in a balanced layout. As a result, the layout emphasizes the interconnections and clusters within the network, allowing for a comprehensive understanding of the central communities and their influential actors (see zoomed-in view of Fig 2).

Key Climate security actors on Twitter

Considering the Twitter mentions network pertaining to climate security discourse (Fig 2), Table 1 presents the top five key user in each of the three categories considered to be opinion leaders, namely influencers, network builders, and information bridges, along with their respective institutional category. The frequency metric indicates the prevalence of these profiles within the dataset, considering both their role as content creators and their mentions by other profiles. The degree metric quantifies the number of connections each user possesses within the network, with in-degree representing mentions received by the user and out-degree representing mentions made by the user. This comprehensive overview provides valuable insights into the influential actors shaping the climate security conversation and their respective roles within the network.

Table 1. Most prominent opinion leaders for each type (influencer, information bridge and network builder) in the Twitter mentions network.

Id	Role	Frequency	Betweenness centrality	In-degree	Out-degree	Institutional category
UN	Conversation starter	1588	2137337	600	5	UN System

antonioguterres	Conversation starter	448	0	231	0	UN System
UNEP	Conversation starter	430	569381.6	215	8	UN System
EUClimateAction	Conversation starter	271	502398.3	86	10	Regional government
POTUS	Conversation starter	206	0	107	0	Supranational government
UNPeacebuilding	Influencer	1282	2,876,454	299	171	UN System
CntrClimSec	Influencer	1249	4,148,137	311	245	Think tank
SIPRIorg	Influencer	1035	2,727,047	227	162	Think tank
adelphi_berlin	Influencer	625	1,785,611	150	85	Think tank
CGIAR	Influencer	560	457,375	80	56	Research
UNDP	Information Bridge	644	1,739,722	224	39	UN System
ipinst	Information Bridge	478	2,699,651	122	125	Think tank
UN_PGA	Information Bridge	458	676,617	181	46	UN System
UN_Women	Information Bridge	365	2,301,875	118	12	UN System
UNDPPA	Information Bridge	232	261,114	124	14	UN System
EnvPeacebuild	Network builder	1170	2,349,211	60	441	Multi-stakeholder platform
ClimateDiplo	Network builder	805	3,829,032	84	328	Think tank

FlorianKrampe	Network builder	678	1,834,434	68	264	Think tank
PlanSecu	Network Builder	632	2,555,344	93	224	Think tank
NewSecurityBeat	Network Builder	461	1,512,998	93	69	Think tank

Data is sorted by opinion leader type (influencer, information bridge and network builder) and then by frequency within each type.

Considering the climate security debate on Twitter, the Twitter profiles that were most frequently called into conversations are strongly related to very high level policy actors, such as the central United Nations profile (@UN), the UN Secretary General António Guterres (@antonioguterres), and the USA president (@POTUS), but also supra-national climate-related institutions like the United Nations Environment Program (@UNEP) and the European Commission's Directorate-General for Climate Action (@EUClimateAction). These conversation starters are frequently mentioned in tweets related to climate security and are also often the authors of tweets that instigate a debate. They play a part in controlling the flow of information in the network.

The profile for United Nations Peacebuilding (@UNPeacebuilding), the think tanks The Center for Climate and Security (@CntrClimSec), and adelphi (@adelphi_berlin), as well as the research institutions Stockholm International Peace Research Institute (@SIPRIorg) and CGIAR (@CGIAR) are the five most influential actors in the network of mentions. These accounts are highly active in the conversations, as they are mentioned by several other actors, but also mention many accounts. This indicates an elevated level of bi-directional dialogues, with these users having a significant impact on the network's dynamic. It is not surprising as these actors have been instrumental in leading to the establishment of a climate security community of practice, pioneering research, and informing operational and programming work on the ground.

The global multi-stakeholder platforms Environmental Peacebuilding Association (@EnvPeacebuild), Climate Diplomacy (@ClimateDiplo) and the Planetary Security Initiative (@PlanSecu), as well as the Director of the Climate Change and Risk Program at the Stockholm International Peace Research Institute (@FlorianKrampe) and the blog of the Wilson Center's Environmental Change and Security Program are network builders. These accounts connect with and link other influencers in the network.

The United Nations bodies UN Development Program (@UNDP), the Presidency of the General Assembly (@UN_PGA), UN Women (@UN_Women), UN Department of Political and Peacebuilding Affairs (@UNDPPA), and the think tank International Peace Institute (@ipinst) are information bridges. These accounts connect active engagers – who are key propagators of information – with influencers in the network and are considered a source of information for other users.

Placing CGIAR within the climate security network

To understand CGIAR's position in the climate security discourse on Twitter, as well as gain insights on the extent to which it has engaged with relevant actors, we constructed an ego network comprising accounts associated with the CGIAR system. From the entire mentions network, 290 accounts were identified, which displayed 916 interconnections. These accounts include the CGIAR-related profiles. Fig 3 provides a comprehensive representation of this ego network union, accompanied by detailed zoomed-in views of its three most relevant clusters. These clusters consist of: (A) the cluster centered around the main official @CGIAR account, (B) the central cluster housing five identified key users, (C) the @CGIARclimate account cluster, and (D) the @EnvPeaceBuilding cluster.

Fig 3. **Network graph representing the links of CGIAR to other accounts in the Twitter mentions network.** The illustration provides a zoom on four different regions of the CGIAR ego network.

Drawing on the concepts of visual network analysis [4] and the positional centrality of the nodes corresponding to CGIAR accounts (shown in green), we observed that the accounts subjected to a force-driven algorithm moved around the fixed ones. This allows us to examine the relationship between key users (orange) and common accounts (yellow) in relation to CGIAR accounts. The network analysis of CGIAR's accounts highlights the presence of influential users within their network, with certain accounts demonstrating higher levels of connectivity and engagement. Node sizes were determined by frequency, illustrating the prominence of these accounts.

The first finding shown in Fig 3 (panel A) is the prominence of the Alliance of Bioversity International and CIAT (@BiovIntCIAT_eng) in the climate security community. As mentioned, the Alliance has been leading the work on climate, peace and security since 2019 and now accounts for a broad team of interdisciplinary researchers and a large portfolio of projects in Fragile and Conflict Affected States (FCASs). This work has been published in internationally renowned journals such as The Lancet and supported by the CGIAR Management team represented during early years by Kundavi Kadiresan.

Panel b shows the connections of CGIAR FOCUS Climate Security to other key actors in the climate security space. The central location of this cluster in the network indicates that several CGIAR accounts are linked to these nodes. Among them we find the Climate Diplomacy by Adelphi, which was one of the first institutions CGIAR collaborated with for research on the nexus

as well as the United Nations and the UNDP. The CGIAR account most connected to opinion leaders is the CGIARclimate account, linked to the United Nations (UN) and SIPRIorg as a source node, 12 and 10 times, respectively. Additionally, the CGIAR account was mentioned by SIPRIorg 10 times. Furthermore, the PlanSecu account was frequently mentioned by the CGIAR account (24 times).

In panel c, the CGIAR profile for its Climate Impact Platform is prominent, representing the frequent engagement of climate action-focused activities in the conversations liked to peace and security. Lastly, panel d highlights the connections to Environmental Peacebuilding Association (@EnvPeacebuild).

Discussion

As individuals and organizations mention one another, they create networks of information flows, and these connections define the boundaries of a topic network [9]. The high modularity detected by the Louvain algorithm [46] in this analysis indicates a unified structure within the clusters, but reveals that nodes are not well connected across communities. Given that more than 1,200 clusters were determined, where the eight largest groups comprise 40% of the network, there is a high level of segregation between communities - i.e., limited dialogue among different actors that may be interacting within established echo chambers [50].

The analysis of key actors aimed to identify the profiles that influence and shape discourses within the thematic network of climate security. Such “online leaders” can “trigger feedback, spark conversations within the community, or even shape the way that other members of a group ‘talk’ about a topic” [6]. As such and considering the current context of an increased number of actors

wishing to enter the climate security space, it is relevant to understand who the established players already engaged in debate are and how knowledge and information are being shared among them.

According to the typology proposed by Rehman et al. [18], influencers are the strongest actors within a network, with many isolates mentioning them or engaging with their content. They are considered agenda setters and key sources of information within the network. The communities formed around them are usually the most prominent and help in the dissemination of information to the network.

In our analysis, the actors identified within these categories are high level United Nations profiles and institutional accounts of research institutes and think tanks from the Global North, which is an indication that the climate security agenda is largely driven by established institutions and that the accepted knowledge on the topic is mainly diffused in top-down dynamics.

These findings point to a gap in the development of an inclusive environment for knowledge generation and the advancement of climate security issues that embrace non-hegemonic views and realities. More specifically, despite efforts to overcome top-down and siloed approaches to frame the relationship between climate change, peace and conflict, individuals and organizations from the Global South who may be the most affected by climate change and insecurity risks and who should be brought to the table for the co-creation of a cohesive climate security narrative and related agenda have not been engaged in the public discussions happening on social media.

Our findings also show this analysis can become a useful resource for CGIAR to strengthen its engagement and visibility by providing evidence on who the main and most central actors are in this space. This is particularly important as society progresses towards a polycrises area, where

climate and security crises converge and reinforce each other, creating the need for strong humanitarian, development, and peace collaborations.

Specifically, relevant key actors that CGIAR should more actively engage with include the UN Secretary General António Guterres (@antonioguterres), the United Nations Environment Program (@UNEP), the European Union Climate Action (@EUClimateAction), the President of the United States (@POTUS), United Nations Peacebuilding (@UNPeacebuilding), the Center for Climate and Security (@CntrClimSec), the Stockholm International Peace Research Institute (@SIPRIorg), Adelphi Berlin (@adelphi_berlin), the United Nations Development Program (@UNDP), the International Peace Institute (@ipinst), the President of the United Nations General Assembly (@UN_PGA), UN Women (@UN_Women), and the United Nations Department of Political and Peacebuilding Affairs (@UNDPPA).

Our study has limitations that we wish to draw attention to. First, we used Twitter data to identify relevant entities participating in climate security debates, an approach which may not capture all potential actors, such as the digitally excluded. This is particularly true when considering regional organizations and national actors, particularly those located in the Global South, who may not appear in the analysis although they are currently playing a crucial role in influencing and further shaping climate security debates regionally, nationally, as well as locally.

Also, we used English, French, and Spanish terms to develop the query applied on Twitter to create the dataset. Thus, data possible do not include tweets in other languages, i.e., tweets in Arabic only containing hashtags in Arabic. All-language tweets containing the hashtags listed in were not excluded [40].

While this study analyzed Twitter networks, future studies may apply this model to other social media platforms such as Instagram and Telegram, and news media. In addition, SNA can

be combined with content analysis for a deeper understanding not only of the actors involved, but also of the discourses and framings being disseminated.

Conclusion

Recognizing social media as spaces for the mobilization of publics around social issues and causes [51], in this study we relied on Twitter to uncover the networks formed around conversations about climate, peace and security, and the dynamics among the actors involved. We have identified key profiles participating in these public debates on Twitter by applying network statistical measures (such as betweenness centrality, in-degree, out-degree) and prioritizing original tweets over retweeted content to focus on interactions rather than popularity.

Our analysis shows how information about climate security was disseminated in the Twitter platform between 2014 and 2022, and indicates the key actors who begin conversations, who connect with various profiles, or who are mentioned frequently. Mapping these profiles helps further understand the emerging climate security landscape, and to identify the institutions and public figures engaged in advancing the climate security discussion. Results show that, on social media, the climate security debate is still largely happening at the institutional level, i.e., with research institutions and international organizations at the center of the discussion, and that distinct communities within the network are not highly interconnected. This reveals a potential gap in generating an inclusive climate security agenda.

Regarding CGIAR's position within the broader network, analysis uncovered linkages of the consortium with prominent actors in the network, but also pointed to stronger connections that could be developed, namely around UN agencies and think tanks. As climate security continues to

gain salience within research and policy arenas, understanding the discursive landscape can reveal entry points for effective engagement and partnership building.

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Supporting information

S1 Table. List of CGIAR profiles on Twitter.

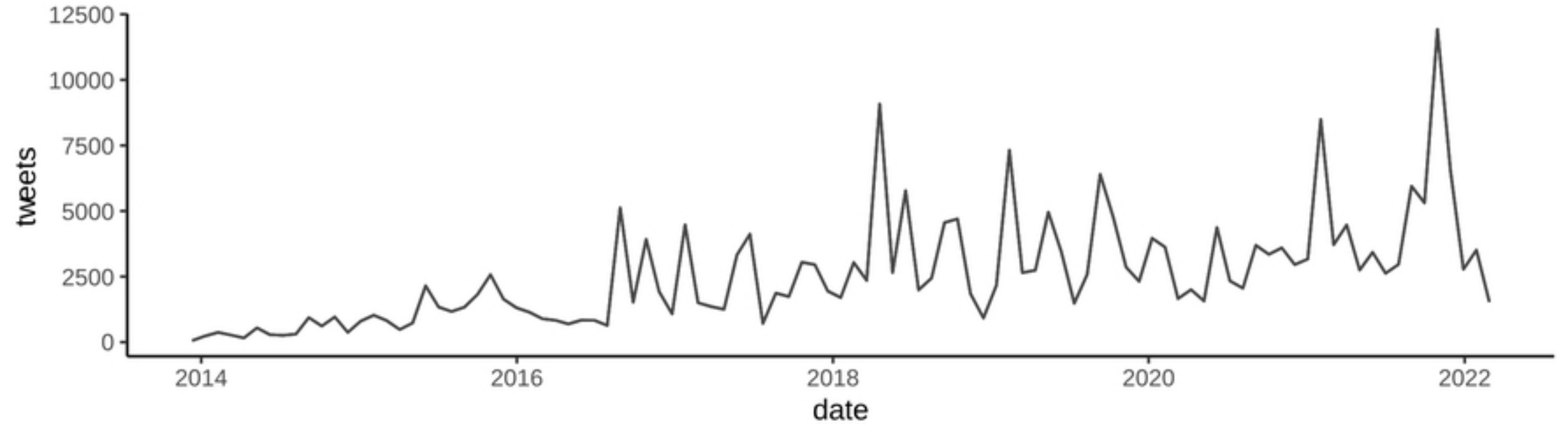

12500
10000
7500
5000
2500
0
tweets
2014
2016
2018
2020
2022
date

Figure 1

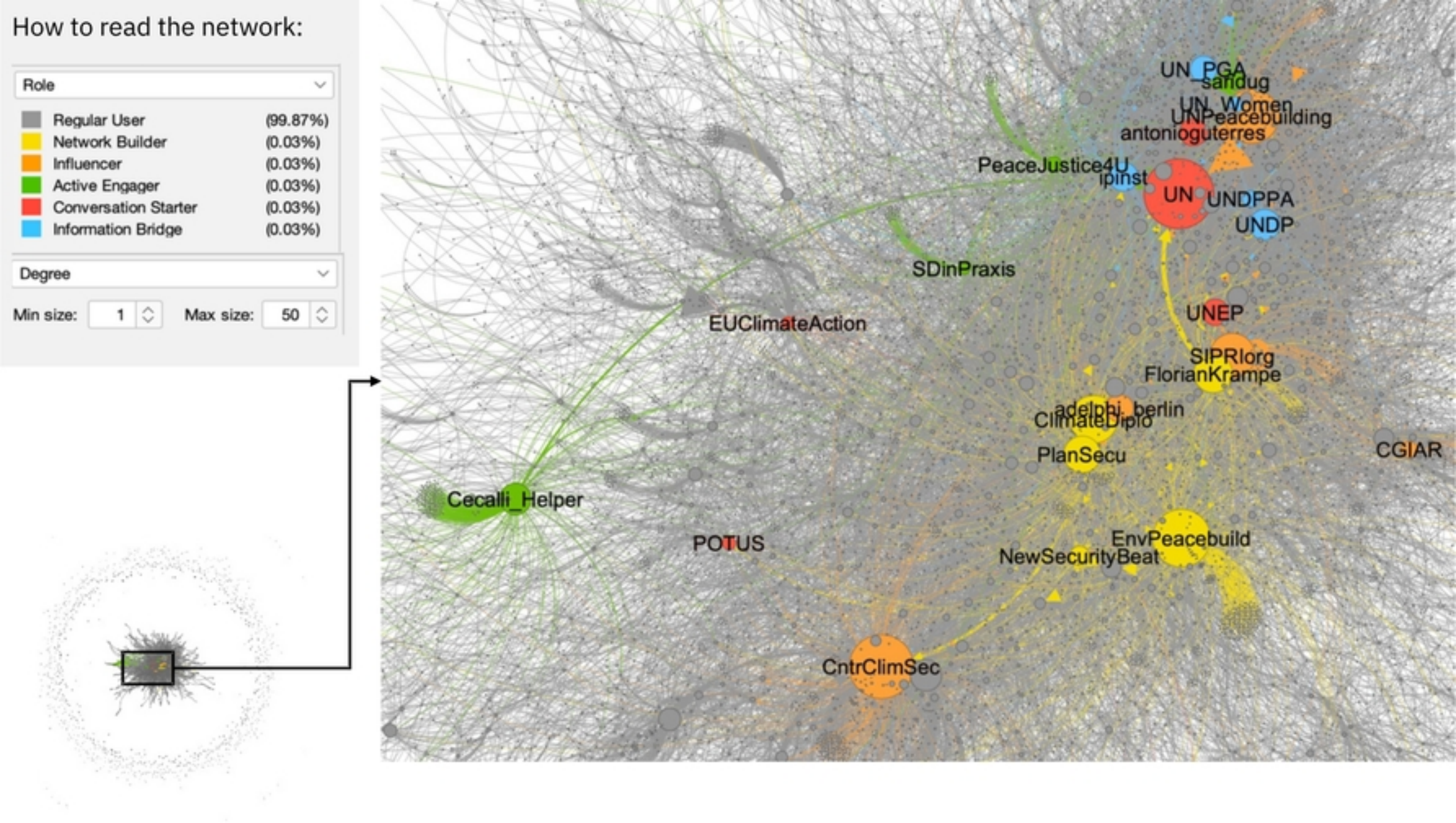
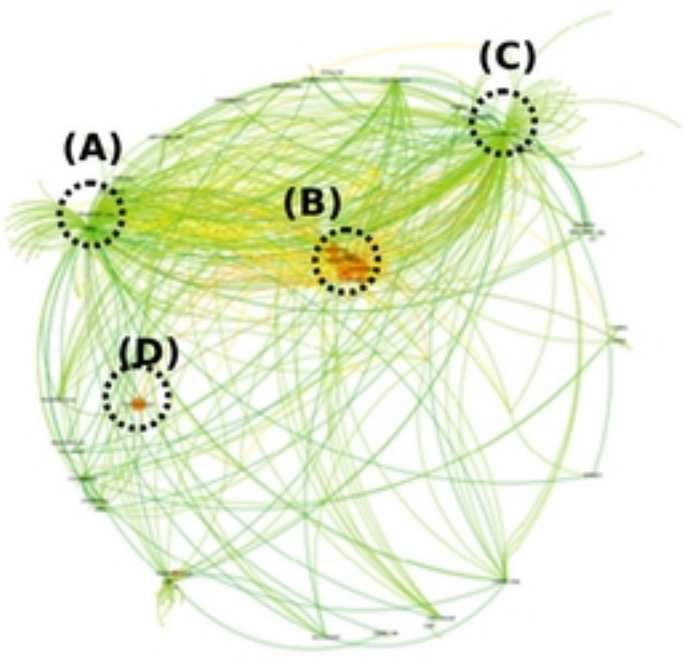

How to read the network:
Role
Regular User (99.87%)
Network Builder (0.03%)
Influencer (0.03%)
Active Engager (0.03%)
Conversation Starter (0.03%)
Information Bridge (0.03%)
Degree
Min size: 1
Max size: 50
UN_PGA
sanjug
UN_Women
UNPeacebuilding
antonioguterres
PeaceJustice4U
ipinst
UN
UNDPPA
UNDP
SDinPraxis
EUClimateAction
UNEP
SIPRIorg
FlorianKrampe
adelphi_berlin
ClimateDiplo
PlanSecu
CGIAR
Cecalli_Helper
POTUS
EnvPeacebuild
NewSecurityBeat
CntrClimSec

Figure 2



Reading the network:

Nodes: 290

Edges: 916

Directed Graph

other	(86.21%)
CGIAR	(11.72%)
key user	(2.07%)

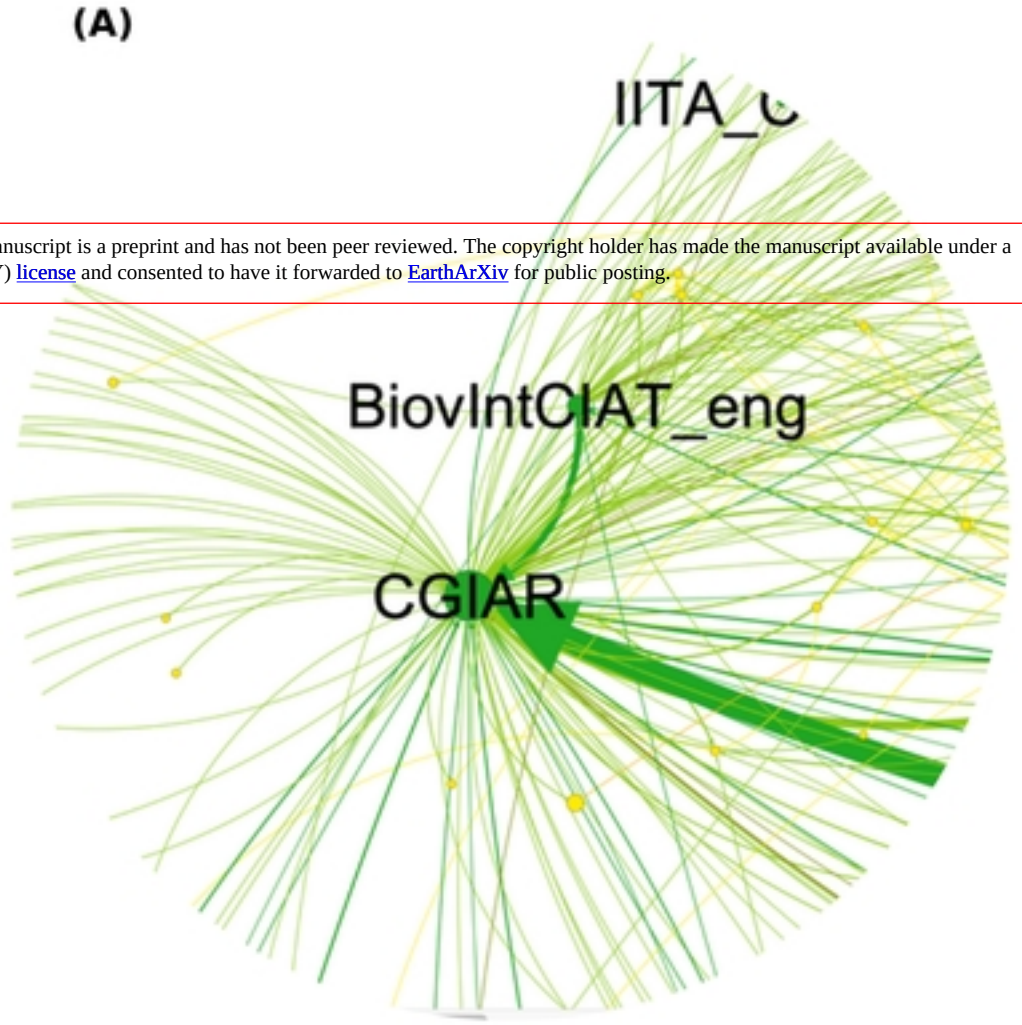
Frequency:

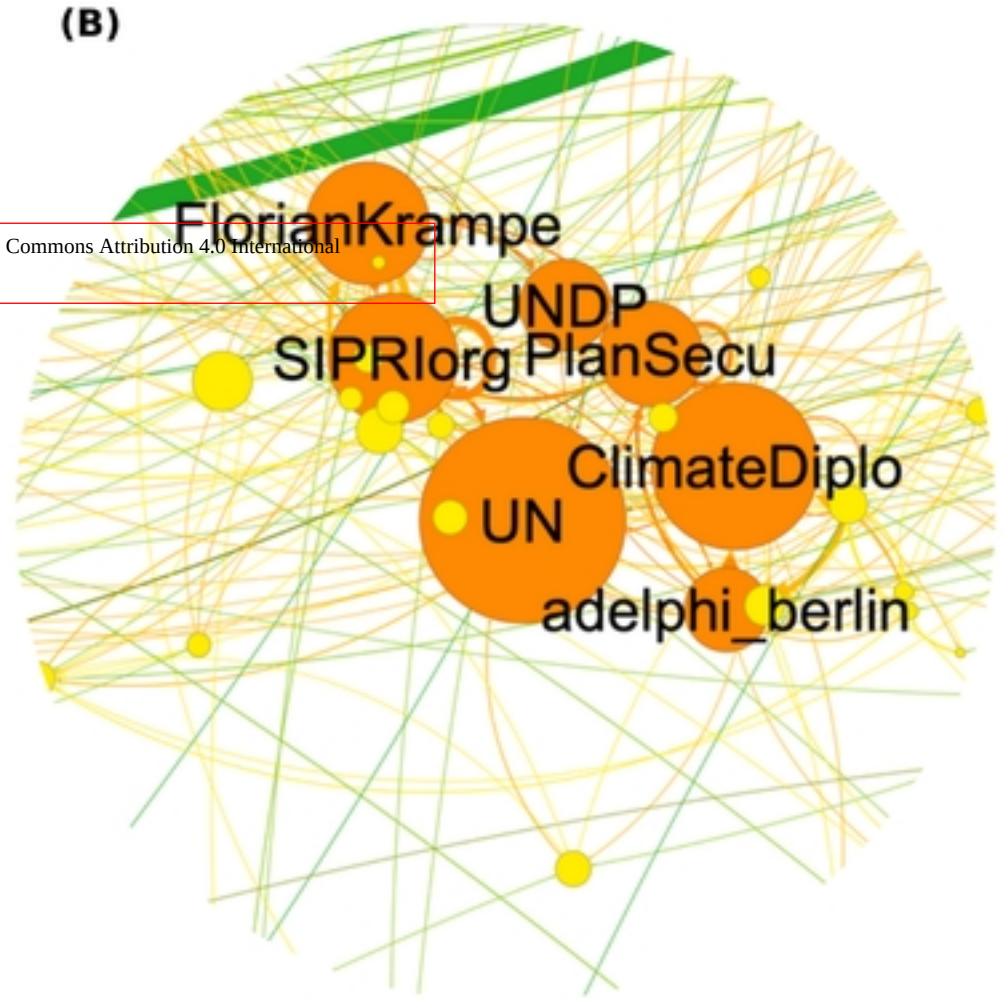
1

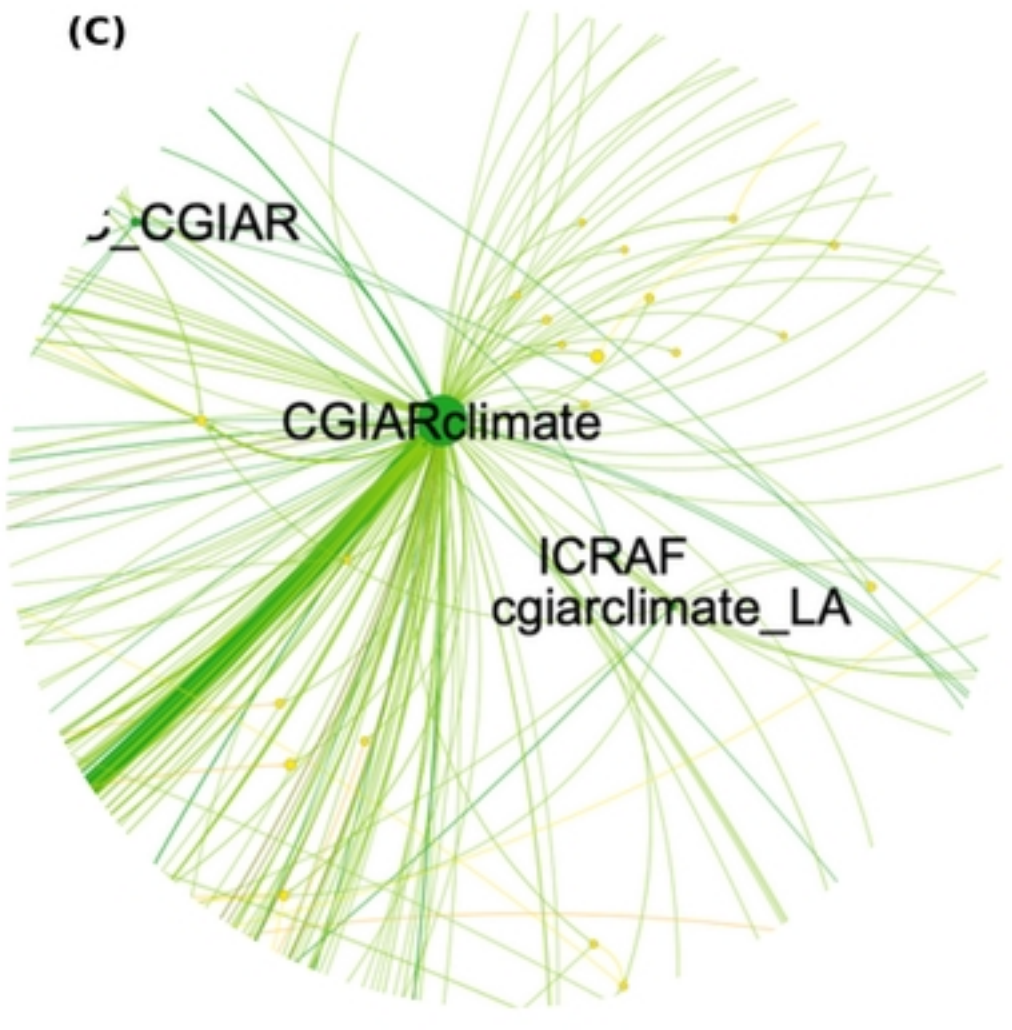
250

Key users figuring on the network:

UN	Conversation starter
SIPRIorg	Influencer
adelphi_berlin	Influencer
UNDP	Information Bridge
ClimateDiplo	Network
NewSecurityBeat	Network
EnvPeacebuild	Network Builder
FlorianKrampe	Network Builder
PlanSecu	Network Builder







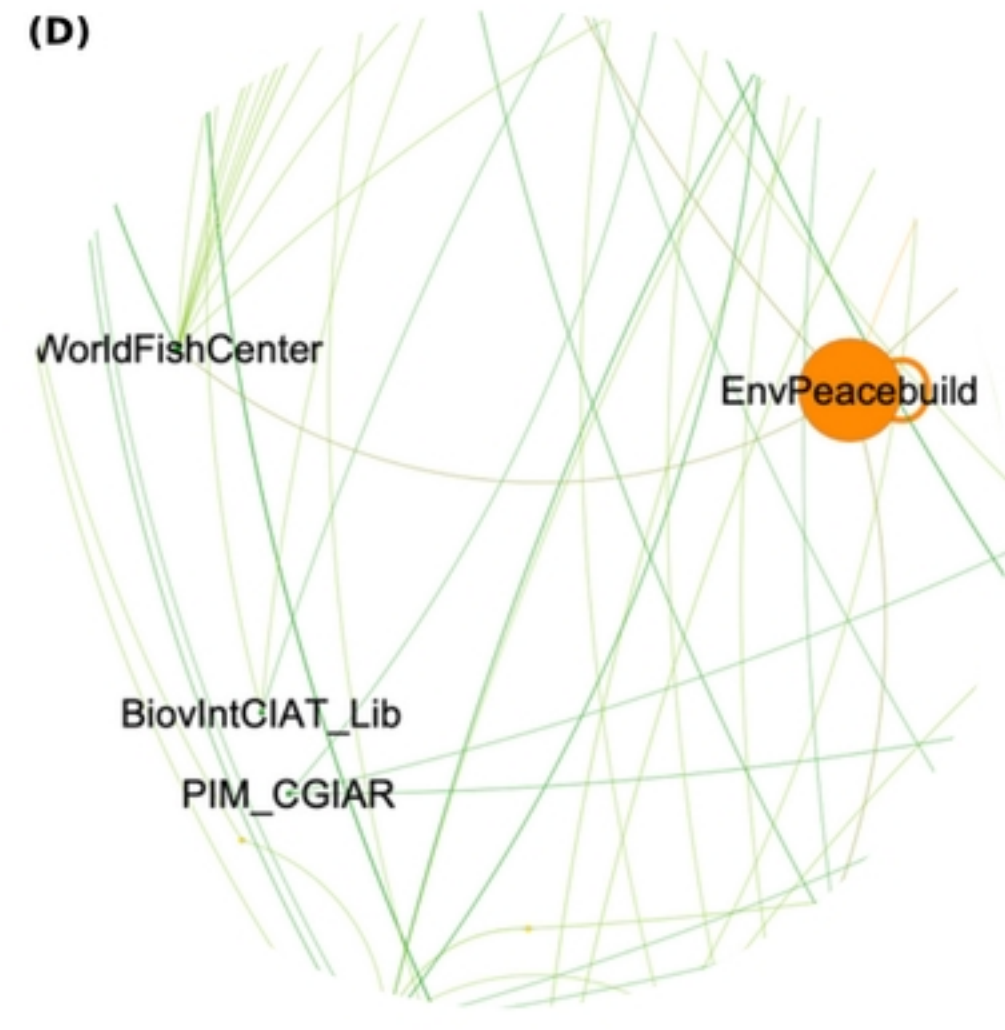


Figure 3